BEFORE THE

Federal Communications Commission

WASHINGTON, D.C. 20554

In the Matter of	)	
	)	
The Establishment of Policies and Service	)	IB Docket No. 01-96
Rules for the Non-Geostationary Satellite Orbit	)	
Fixed-Satellite Service in the Ku-Band	)	

To: The Commission

COMMENTS OF VIRTUAL GEOSATELLITE LLC

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Summary

Virtual Geosatellite LLC ("Virtual Geo") shares the Commission's objective in this proceeding of licensing all of the current applicants, thereby ensuring that market forces determine which operators ultimately provide service rather than the Commission itself dictating which technology will be employed. In order to meet this objective, the Commission must establish a workable framework for spectrum assignment that provides a fair opportunity for all current applicants to proceed with their plans, and also provides opportunities for potential future entrants.

Accommodation of homogeneous VGSO constellations is an essential element of any plan that can be found to be consistent with this goal, and with the promotion of competition and efficient spectrum use. VGSO technology maximizes spectrum efficiency, both in terms of ensuring compatible operation of multiple NGSO systems with existing GSO satellite systems, and in terms of securing opportunities for future entry. Unlike other system proposals, the VGSO model allows for a large number of homogenous NGSO systems to coexist in the spectrum that is used today by GSO FSS and BSS systems. This provides alternative options both for service providers currently unable to provide new service in the congested GSO arc, and for satellite services users in geographic locations that are able to obtain line of sight to GSO satellites only from low elevation angles. The prospects for this spectrum use opportunity are so extensive that adoption of a VGSO requirement across all of the available spectrum would leave open many additional opportunities for future service, even after all applicants in the present round are assigned licenses for global coverage systems. Accordingly, if the Commission were compelled to adopt only one technical approach to development of Ku-band NGSO systems, the selection of the VGSO model as a standard for all such systems would be most consistent with

the public and national interests – even after considering the consequential requirement for all non-VGSO applicants to conform to the VGSO parameters.

Virtual Geo nonetheless recognizes that allotting all available Ku-band NGSO spectrum for use by VGSO systems, while maximizing the long-term utility of the spectrum, would not permit all of the current applicants an opportunity to proceed with the specific technical approaches that they have advocated. In view of the Commission's desire to make provision within its rules for each of the distinct technological approaches placed before it by NGSO Ku-band applicants in the current processing round, Virtual Geo believes that the most practical way forward would be for the Commission to adopt a hybrid assignment mechanism. Specifically, Virtual Geo calls upon the Commission to segment the available spectrum between two of the spectrum sharing approaches identified in the *NPRM* – (1) mandated homogeneous constellations employing VGSO architecture, and (2) coordinated avoidance of in-line interference events.

Adoption of the homogenous constellations approach for one portion of the band would allow a large number of VGSO networks to operate in the same spectrum, while use of coordination schemes to avoid in-line interference events in a separate spectrum segment would allow a smaller number of non-homogenous systems to operate compatibly. Under this approach, the spectrum set aside for VGSO NGSO systems could accommodate Virtual Geo, all of the other current applicants (should they opt to employ the VGSO model), and even future VGSO systems. At the same time, however, this approach would also provide each of the current applicants with the opportunity to decide under which of the spectrum use models it would prefer to be licensed.

A hybrid assignment approach may be the only feasible means of accomplishing all of the Commission's objectives, and ensuring that all of the applicants have both an opportunity to pursue their plans and sufficient spectrum within which to operate successfully. Conversely, adoption of a plan that does not include specific spectrum for VGSO development would waste a rare opportunity to enhance use of the Ku-band spectrum. In effect, the capacity to be derived from the Ku-band NGSO spectrum would be capped, defined solely by the capabilities of the systems in the present processing round, without provision for future growth. Ensuring opportunities for additional competition through assignment of spectrum for VGSO operations will have substantial public benefits, allowing the aggregate capacity of Ku-band NGSO systems to expand as demand warrants, thereby keeping user costs low.

Establishing two separate bands for development of distinct types of Ku-band NGSO FSS systems will also resolve potential mutual exclusivity among the current applicants, allowing each one to be licensed for whichever technical approach it deems most advantageous. The establishment of spectrum zones based on both VGSO and in-line avoidance techniques will also leave room not only for systems licensed by other administrations to operate consistent with either of these two approaches, but will also leave ample opportunities for licensing of future systems, both domestically and through foreign administrations. Indeed, because of the standardization of the VGSO orbital parameters, the Commission will be able to accept new applications for VGSO systems immediately after licensing of the first round applicants without opening up a protracted and cumbersome processing round, because it will be in a position to assign VGSO licenses quickly to qualified applicants. Provision of opportunities for new entrants should also ameliorate concerns by other countries that Commission licensing of multiple operators will unduly constrain the ability of other countries to license Ku-band NGSO systems.

Finally, segmenting the Ku-band spectrum available for NGSO FSS operation will simplify the resolution of the remaining regulatory issues before the Commission – both in the short term, and as satellite systems are launched and become operational. In other words, setting ground rules at the beginning for two separate frequency bands will provide greater certainty to the applicants and minimize the prospects for post-licensing disputes among system licensees, reducing the possibility that the Commission may be called upon at a later time to resolve coordination disputes between operators.

Virtual Geo's specific spectrum allotment proposals for VGSO and non-VGSO systems are depicted in the chart at the end of this summary. The plan that Virtual Geo is proposing provides for an equal amount of spectrum to be allotted for each type of NGSO system with a small buffer of spectrum between the two bands to serve as a "growth zone" for expansion of service by one or both types of systems as demand grows.

Virtual Geo proposes a definition of a "VGSO system" for purposes of determining access to the VGSO spectrum band, and identifies the critical parameters of the orbital configuration. Homogeneity is essential within the VGSO zones if the benefits of the technology are to be realized.

The approach Virtual Geo proposes here is not radically different from the technical regulatory requirements for GSO FSS satellites, where licensees are, in effect, required to fly their satellites in an FCC-mandated manner, spaced two degrees from adjacent operators. The Commission has come to recognize that these "rules of the road," *i.e.*, spacing and orbital requirements for GSO networks, best serve the public interest. The GSO satellite industry and the public-at-large have benefited greatly from this sound technical paradigm that has evolved (and is still evolving in some cases) for use of the GSO arc. The Commission should pursue the positive benefits of a standard regulatory approach in this instance as well, and establish an assignment scheme that permits full achievement of the similar but even more extensive benefits from Ku-band NGSOs by committing a portion of the available spectrum to VGSO use, requiring licensees to adopt the critical technical characteristics necessary to maximize spectrum utility and preserve opportunities for future entry.

VIRTUAL GEO Ku-BAND ASSIGNMENT PLAN PROPOSAL

GATEWAY UPLINK BANDS

12.75-13.15 GHz and 13.2125-13.25 GHz		**# MHz**
VGSO Zone	12.75-12.960 GHz	210
Growth Zone	12.960-12.9775 GHz	17.5
Non-VGSO Zone	12.9775-13.15 & 13.2125-13.25 GHz	210

13.75-14.0 GHz		**# MHz**
VGSO Zone	13.75-13.865 GHz	115
Growth Zone	13.865-13.885 GHz	20
Non-VGSO Zone	13.885-14.00 GHz	115

USER UPLINK BAND

14.00-14.50 GHz		**# MHz**
VGSO Zone	14.00-14.24 GHz	240
Growth Zone	14.24-14.26 GHz	20
Non-VGSO Zone	14.26-14.50 GHz	240

GATEWAY DOWNLINK BAND

10.7-11.7 GHz		**# MHz**
VGSO Zone	10.70-11.175 GHz	475
Growth Zone	11.175-11.225 GHz	50
Non-VGSO Zone	11.225-11.70 GHz	475

USER DOWNLINK BAND

11.7-12.7 GHz		**# MHz**
Non-VGSO Zone	11.70-12.175 GHz	475
Growth Zone	12.175-12.225 GHz	50
VGSO Zone	12.225-12.70 GHz	475

SPECTRUM TOTALS

	GATEWAY LINKS		**USER LINKS**		**TOTAL**
ZONE TYPE	**UP**	**DOWN**	**UP**	**DOWN**	
VGSO	**325 MHz**	**475 MHz**	**240 MHz**	**475 MHz**	**1515 MHz**
Growth	**37.5 MHz**	**50 MHz**	**20 MHz**	**50 MHz**	**157.5 MHz**
Non-VGSO	**325 MHz**	**475 MHz**	**240 MHz**	**475 MHz**	**1515 MHz**

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To: The Commission

COMMENTS OF VIRTUAL GEOSATELLITE, LLC

Virtual Geosatellite, LLC ("Virtual Geo"), by counsel and pursuant to Sections 1.415 and 1.419 of the Commission's Rules, hereby comments on the Commission's *Notice of Proposed Rule Making* in the above-captioned docket (the "*NPRM*"). Virtual Geo is an applicant for authority to provide nongeostationary ("NGSO") fixed-satellite service ("FSS") in the Ku-band. It has been an active participant for more than two years in domestic and international proceedings concerning the most advantageous means of introducing such new services into the frequency bands currently used by geostationary ("GSO") FSS and broadcasting-satellite service ("BSS") systems. Accordingly, Virtual Geo welcomes this opportunity to provide input concerning the adoption of the assignment policies and service rules necessary to make Ku-band NGSO FSS satellite services a reality.

I. INTRODUCTION AND STATEMENT OF INTEREST

A. Statement of Interest

On January 8, 1999, Virtual Geo filed an application with the Commission seeking authority to launch and operate a constellation of non-geostationary satellites to provide affordable, state-of-the-art, digital fixed-satellite services to a broad range of users.[1] The services provided would include high-speed Internet access, video and broadband data distribution, and two-way video conferencing. Virtual Geo's proposed "Virgo" system would utilize a combination of user and gateway links in the C-band and Ku-bands, as well as inter-satellite links in optical frequencies.

Unlike most of the other NGSO FSS system proposals that have been advanced, the Virtual Geo's Virgo system is premised upon use of satellites in elliptical orbits with apogees of approximately 27,000 kilometers. Constellations of satellites operating in these carefully-calibrated orbits produce repeating ground tracks, allowing them to operate as continent-following arrays that appear stationary to users on the Earth, much as satellites in equatorial orbits function in GSO orbits. Virtual Geo calls this phenomenon a "virtual geostationary satellite orbit" or VGSO.

Satellites deployed in a VGSO are effectively transparent to co-frequency GSO systems because the active satellites do not come within 40 degrees of the GSO arc and are therefore able to avoid operational-phase orbital intersections. For this reason, VGSO satellite networks do not pose any sharing difficulties for GSO systems, and allow the repeated reuse of valuable spectrum resources.

In effect, the use of VGSO orbits creates a new orbital resource in which specific operational opportunities can be assigned in effectively the same manner that orbital "slots" are assigned in the GSO arc. As a result, many VGSO systems can be licensed to operate in the same frequency bands by reusing the spectrum in each VGSO operating window. As detailed

1 *See* Application of Virtual Geosatellite, LLC, FCC File No. SAT-LOA-19990108-00007, filed January 8, 1999 ("Virtual Geo Application").

more fully below, this approach to use of the orbital and spectrum resources will enhance spectrum efficiency and promote sharing, on a non-interference basis, with both existing GSO FSS operators and other, similarly configured VGSO-type FSS systems.

As an applicant for a uniquely spectrum-efficient type of Ku-band NGSO FSS system, Virtual Geo has a strong interest in the successful resolution in this proceeding of the issues that are involved in the sharing of Ku-band spectrum among multiple technologically distinct satellite systems. A carefully crafted decision in this docket that is consistent with the public interest will ensure the ability to implement VGSO systems, and provide benefits to the public for many years to come.

B. Overview of the Virtual Geo Approach to NGSO-NGSO Sharing at Ku-Band

In the *NPRM*, the Commission establishes three principal objectives to guide its approach to spectrum assignment for new Ku-Band NGSO satellite systems. It states first that it seeks to find a spectrum assignment solution that will permit all applicants to have "equal access to spectrum," ensuring that each system licensed is able to use enough spectrum to operate successfully.[2] Second, the Commission notes its desire to maximize the spectrum that is available to operational systems, preventing spectrum warehousing while at the same time providing sufficient flexibility to ensure that all licensed systems will be accommodated once they commence operations.[3] Third, the Commission desires to provide certainty to system licensees while at the same time avoiding impediments to coordination that would allow shared use of spectrum by multiple operators.[4]

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2 *NPRM*, FCC 01-134, slip op. at 7 (¶ 17).

3 *See NPRM*, FCC 01-134, slip op. at 7 (¶ 18).

4 *See NPRM*, FCC 01-134, slip op, at 7-8 (¶ 19).

Virtual Geo shares the Commission's objectives and embraces its goal of licensing all of the current applicants, thereby ensuring that market forces determine which operators ultimately provide service rather than the Commission itself dictating which technology will be employed. Pursuit of this goal necessarily requires the adoption of a regulatory approach that accommodates the various technical models advanced by the applicants and is otherwise consistent with the public interest, convenience and necessity. In order to meet its objectives, the Commission must therefore establish a workable framework for specific spectrum assignment that provides a fair and equitable opportunity for all applicants in the current round to proceed with their plans, and that also provides potential future entrants with opportunities for deployment of additional systems.

As Virtual Geo has demonstrated in prior comments before the Commission and in subsequent presentations to Commission staff, accommodation of homogeneous VGSO constellations is an essential element of any plan that can be found to be consistent with these goals. VGSO technology maximizes spectrum efficiency, both in terms of ensuring compatible operation of multiple NGSO systems with existing GSO satellite systems, and in terms of securing opportunities for future industry competition. Unlike other system proposals, the VGSO model allows for a large number of homogenous NGSO systems to coexist in the spectrum that is used today by GSO FSS and BSS systems. This provides alternative options both for service providers currently unable to provide new service in the congested GSO arc, and for satellite services users in geographic locations that are able to obtain line of sight to GSO satellites only from low elevation angles. The prospects for this spectrum use opportunity are so extensive that adoption of a VGSO requirement across all of the available spectrum would leave open many additional opportunities for future service, even after all applicants in the present round are assigned licenses for global coverage systems.

Accordingly, if the Commission were compelled to adopt only one technical approach to development of Ku-band NGSO systems, the selection of the VGSO model as a standard for all such systems would be most consistent with the public and national interests – even after the consequential requirement for all non-VGSO applicants to conform to the VGSO parameters is considered. By authorizing satellite systems to operate in the manner proposed by Virtual Geo, the Commission will be harvesting a spectrum opportunity that is no less significant than the advantageous use of the geostationary orbit that was projected by Arthur C. Clarke in 1948 and brought to fruition in the 1960s with the establishment of the first GSO satellite networks.

Virtual Geo nonetheless recognizes that allotting all available Ku-band NGSO spectrum for use by VGSO systems, while maximizing the long-term utility of the spectrum by multiple operators and promoting competition, would not permit all of the current applicants an equal opportunity to proceed with the specific technical approaches that they have advocated. In view of the Commission's desire to make provision within its rules for each of the distinct technological approaches placed before it by NGSO Ku-band applicants in the current processing round – and thereby allow the marketplace to pick winners[5] – Virtual Geo believes that the most practical way forward would be for the Commission to adopt a hybrid assignment mechanism. Specifically, Virtual Geo calls upon the Commission to segment the available spectrum between the final two spectrum sharing approaches identified in the NPRM – (1) mandated homogeneous constellations employing VGSO architecture, and (2) coordinated avoidance of in-line interference events. Adoption of the homogenous constellations approach for one portion of the band would allow a large number of VGSO networks to operate in the same spectrum, while use of coordination schemes to avoid in-line interference events in a separate spectrum segment

[5] *See NPRM*, FCC 01-134, slip op. at 6-7 (¶ 16).

would allow a smaller number of non-homogenous systems to operate compatibly. Under this approach, the spectrum set aside for VGSO NGSO systems could accommodate Virtual Geo, all of the other current applicants (should they opt to employ the VGSO model), and even future VGSO systems. At the same time, however, this approach would also provide each of the current applicants with the opportunity to decide under which of the spectrum use models it would prefer to be licensed.

A hybrid assignment approach may be the only feasible means of accomplishing all of the Commission's objectives, and ensuring that all of the applicants have both an opportunity to pursue their plans and sufficient spectrum within which to operate successfully. Conversely, adoption of a plan that does not include specific spectrum for VGSO development would waste a rare opportunity to enhance use of the Ku-band spectrum. In effect, the capacity to be derived from the Ku-band NGSO spectrum would be capped, defined solely by the capabilities of the systems in the present processing round, without provision for future growth. Ensuring opportunities for additional competition with new operators, potential new technologies and services through assignment of spectrum for VGSO operations will have substantial public benefits, allowing the aggregate capacity of Ku-band NGSO systems to expand as demand warrants, thereby keeping user costs low.

Establishing two separate bands for development of distinct types of Ku-band NGSO FSS systems will also resolve potential mutual exclusivity among the current applicants, allowing each one to be licensed for whichever technical approach it deems most advantageous. The establishment of spectrum zones based on both VGSO and in-line avoidance techniques will leave room not only for systems licensed by other administrations to operate consistent with either of these two approaches, but will also leave ample opportunities for licensing of future systems, both domestically and through foreign administrations. Provision of opportunities for new entrants should ameliorate concerns by other countries that Commission licensing of multiple operators will unduly constrain the ability of other countries to license Ku-band NGSO systems.

Finally, segmenting the Ku-band spectrum available for NGSO FSS operation will simplify the resolution of the remaining regulatory issues before the Commission – both in the short term, and as satellite systems are launched and become operational. In other words, setting ground rules at the beginning for two separate frequency bands will provide greater certainty to the applicants and minimize the prospects for post-licensing disputes among system licensees, reducing the possibility that the Commission may be called upon at a later time to resolve coordination disputes between operators.

The basic outline of the plan that Virtual Geo is proposing is the same assignment plan that Virtual Geo presented to the Commission in January of this year.[6] The plan provides for an equal amount of spectrum to be allotted for each type of NGSO system with a small buffer of spectrum between the two bands to serve as a "growth zone" for expansion of service by one or both types of systems as demand grows. The specific spectrum allotments are depicted in the chart on the next page:

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[6] *See NPRM*, FCC 01-134, slip op. at 14 (¶ 44) & n.54 (citing Virtual Geosatellite, LLC Notifications of *Ex Parte* Presentations in ET Dkt. No. 98-206, January 22, 2001 and January 24, 2001).

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Virtual Geo has considered its spectrum proposals very carefully. It notes, in particular, that it has proposed to place non-VGSO user downlinks outside the 12.2-12.7 GHz band in light of the fact that VGSO systems are more readily capable than low-Earth orbit NGSO FSS of sharing spectrum with terrestrial systems of the design advanced by Northpoint Technology, Ltd. in the new Multichannel Video Distribution and Data Service ("MVDDS") that was established last year for operation in the 12.2-12.7 GHz band.[7]

Virtual Geo proposes that for purposes of determining access to the VGSO spectrum band, the Commission define a VGSO system as an NGSO satellite system or network in which satellites in "virtual slots"[8] transmit or retransmit radio communication signals only while within a region of space located at high latitude (either Northern or Southern) that rotates with the Earth (one rotation a day) and while separated from the geostationary-satellite orbit by at least 40°. Further, in order to be included within a VGSO system or network, a satellite must move in a sub-geosynchronous orbit characterized by specific parameters. These parameters include specified values of mean motion, orbital inclination and eccentricity, argument of perigee, active arc span, longitude of apogees, semi-major axis, relative mean anomaly, and relative right ascension of ascending node. The specific characteristics for each of these parameters are outlined more fully in Section II.A.1, below.

Homogeneity is essential within the VGSO zones if the benefits of the technology are to be realized. Failure to provide significant dedicated spectrum for development of homogeneous VGSO systems would squander the unique capability of these systems to reuse

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7 *See Amendment of Parts 2 and 25 of the Commission's Rules to Permit Operation of NGSO FSS Systems Co-Frequency with GSO and Terrestrial Systems in the Ku-Band Frequency Range,* FCC 00-418 (released Dec. 8, 2000).

8 For purposes of this definition, a virtual slot is defined as the angular interval of longitude required to achieve at least 2° spacing (or another value set by regulation) for the ground central angle. Further details are provided in the discussion below.

spectrum. The approach proposed here is not radically different from the technical regulatory requirements for GSO FSS satellites. The effect of the GSO standards is that licensees are required to fly their satellites in an FCC-mandated manner, spaced two degrees from adjacent operators. The Commission has come to recognize that these "rules of the road," *i.e.*, spacing and orbital requirements for GSO networks, best serve the public interest. The GSO satellite industry and the public-at-large have benefited greatly from this sound technical paradigm that has evolved (and is still evolving in some cases) for use of the GSO arc. The Commission should pursue the positive benefits of a standard regulatory approach in this instance as well, and establish an assignment scheme that permits full achievement of the similar but even more extensive benefits from Ku-band NGSOs by committing a portion of the available spectrum to VGSO use.

Among other benefits, the availability of new licensing opportunities for FSS systems can alleviate the spectrum crunch that exists due to ever-increasing private sector demands for new frequency allocations. To the extent that government spectrum users, such as the Department of Defense, are concerned about loss of existing spectrum to commercial users, the advent of new prospects to make efficient use of bands already in use can open up significant new options to meet national security and other vital public needs.

II. DISCUSSION

A. Virtual Geostationary Orbits Are The Superior Solution From Both A Technical And Regulatory Perspective.

1. The Use Of Homogeneous Constellations Of The Virtual Geostationary Satellite Design Maximizes The Efficient Use Of The Orbital Spectrum Resource And Promotes Multiple Entry, While Avoiding The Pitfalls And Shortcomings Inherent To The Other Approaches Identified In The NPRM.

In the *NPRM*, the Commission proposes four possible approaches to licensing of Ku-band NGSO FSS systems. Of these four possibilities, by far the most advantageous spectrum assignment mechanism is the one based on the ITU determination that the number of NGSO FSS systems that can share the same frequency band without interference increases dramatically when each system employs nearly identical orbital parameters.[9] This approach is the basis for the VGSO system model advanced by Virtual Geo, and constitutes the soundest premise upon which the Commission can proceed with NGSO FSS Ku-band licensing. Mandatory use of the homogenous VGSO parameters in at least a portion of the available spectrum will promote the public interest by establishing a new spectrum-efficient model for delivery of satellite services by the applicants in the current Ku-band NGSO FSS processing round, and by securing additional entry opportunities for future satellite service providers.

As previously discussed, Virtual Geo's system is distinct from the other proposed NGSO FSS systems in that it is premised upon the deployment of a constellation of elliptical orbit satellites with apogees of approximately 27,000 kilometers. The satellites operating in these carefully placed orbits produce repeating ground tracks, allowing them to operate as continent-following arrays that appear stationary to users on the Earth. The placement of these ground tracks allows VGSO systems to avoid intersections with operating GSO satellites while

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[9] *See NPRM*, FCC 01-134, slip op. at 12 (¶ 37) & n.47, *citing* ITU Recommendation S.1431.

the VGSO satellites are transmitting. The apogees of these orbital tracks are at points where the satellites are oriented toward the high latitudes in either the Northern or the Southern Hemisphere, and employ active arcs that have a minimum separation of 40 degrees with respect to GSO satellites at the equator (over the U.S., the minimum separation is 45 degrees). Through the use of standardized orbital parameters, these VGSO constellations effectively establish "virtual slots" from which service can be offered to fixed ground stations oriented to the north in the Northern Hemisphere and to the south in the Southern Hemisphere.

Although VGSO systems will easily achieve compliance with the particular power limits that have been established by the FCC and the ITU for Ku-band NGSO operation that protect both GSO operators and fixed service facilities,[10] the nature of VGSO operation makes unnecessary the specific constraints and operational parameters that are necessary to ensure that sharing between non-VGSO NGSOs and GSO and fixed service systems can occur. With the minimum 40° separation of active VGSO satellites from the GSO arc, circumstances where GSO protection criteria could be exceeded – even from a fully-populated VGSO arc – will be all but impossible.

As a result of these efficiencies, in Ku-band NGSO spectrum that is limited to use by VGSO-type NGSO systems, as many as 180 operating continent-following VGSO satellites, or 30 separate global systems of VGSO satellites can operate simultaneously in the entire allocated spectrum without interference.[11] Alternatively, the VGSO architecture could accommodate an even larger number of systems if some limited their operations to hemispheric,

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[10] *See, e.g., Amendment Of Parts 2 And 25 Of The Commission's Rules To Permit Operation Of Ngso Fss Systems Co-Frequency With Gso And Terrestrial Systems In The Ku-Band Frequency Range*, FCC 00-418, slip op. at 21-23 (¶¶ 38-42) (released Dec. 8, 2000).

[11] This assumes that six VGSO satellites, three each in Northern Hemisphere arcs and in Southern Hemisphere arcs, comprise a "global" system.

regional, or single country service. Each such system reuses the same Ku-band spectrum at its distinct virtual slot, maximizing the amount of spectrum available to each operator.

a. Parameters of VGSO Orbits

Taking advantage of these unique technical attributes will require the establishment of a precise definition of the VGSO spectrum utilization approach and the specific parameters and tolerances that are required to achieve optimal results, as the Commision noted in the *NPRM*.[12] As noted previously, Virtual Geo proposes to define VGSO satellite systems as follows:

> An NGSO satellite system or network in which satellites transmit or retransmit radiocommunication signals while within a defined Virtual Geostationary Space, *i.e.*, a set of high latitude stationary slotted arcs (HLSSA) over the Earth in Earth-centered, Earth-fixed coordinates in which a number of satellites may operate simultaneously while maintaining a minimum specified angular separation from each other (defining a "slot" size) at all times.[13]

Virtual Geostationary Space is itself synchronous with the rotation of the Earth, and always separated from the geostationary arc by at least 40°. In order to be included within a VGSO system or network, a satellite must move in a sub-geosynchronous orbit characterized by specific values of the following parameters – mean motion, orbital inclination and eccentricity, argument of perigee, active arc span, longitude of apogees, and mean anomaly at epoch. Each of these parameters is defined and quantified in the paragraphs below, and a summary of all of the relevant parameters outlined is provided as Appendix 2 to these comments. Virtual Geo proposes that these parameters and their associated values be included in the Commission's rules and applied to NGSO systems that seek to operate in the VGSO zones identified above. *See* Appendix 2, § 25.103(g).

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12 *See NPRM*, FCC 01-134, slip op. at 13 (¶ 40) & n.49.

13 Further details are provided in the discussion below. *See also* Appendix 2, § 25.103(g).

(1) Mean Motion: Mean motion is the number of revolutions around the earth that a satellite makes in one day. An integer value for mean motion ensures that the satellite will repeat the same ground track each day. Because it is desired that all satellites follow a repeating ground track, and each satellite is intended to visit no more than three active arcs, the value selected for mean motion of a VGSO system is three (3).[14]

(2) Inclination: An orbital inclination of 63.435 degrees is the optimal value for VGSO use. This figure prevents the line connecting orbital apogee and perigee ("line of apsides") from rotating around the orbit, and thus moving the apogee southward toward the equator.[15]

(3) Eccentricity: To achieve the benefits of VGSO orbits, orbital eccentricity should be standardized at a value in the range from 0.63 to 0.66 – optimally at the lower end (*i.e.*, 0.63). At the high end of this range is the maximum feasible value that, when combined with the necessary mean motion, yields an apogee of 27,271 kilometers, and a perigee of 513 kilometers. A lower eccentricity would yield lower apogees, higher perigees and less atmospheric drag and intersection with LEO orbits, but slightly lower declinations (angle above the equator from the center of the earth) for the lowest part of the active arc. The number of satellites that can be placed simultaneously in an active arc will increase slightly, but coverage areas may also slightly reduce, due to lower operational satellite altitudes at active arc end points. Within the identified range, eccentricity value has very little effect on the arc characteristics and advantages. Lower eccentricities outside this range move the lower ends of the active arcs closer to the equator, and

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[14] A mean motion of four (4) would produce active arcs that are too broad to maintain the desired regional geographic coverage. A mean motion of two (2) would produce very narrow active arcs such that slotting would be less feasible because positions on the active arc would not have sufficient angular separation.

[15] If the inclination were higher, the line of apsides would rotate in the direction of satellite motion. If the inclination were lower, the line of apsides would rotate around the orbit in the same direction that the satellite moves.

become increasingly less desirable in terms of separation from the GSO arc. Changes in eccentricity have a more dramatic effect on perigee than any other factor, hence the advantages of an increase perigee may push the optimal orbit toward the lower end of the identified range, near 0.63.

(4) Argument of Perigee: For VGSO systems, the Argument of Perigee must be 270 degrees for Northern Hemisphere groundtracks and 90 degrees for Southern Hemisphere groundtracks. These values are important as they determine where the apogees are – *i.e.*, where satellite motion is slowest. These figures place the apogees at the furthest angles in declination from the equator, and keep the active arcs, which span 216 degrees of Mean Anomaly, well separated from the equatorial arc. As the Argument of Perigee departs from these values, the ends of the active arcs will move toward the equator. Some slight variation in argument of perigee from the cited value, on the order of one degree, might be desirable to ensure good satellite spacing at orbit crossings, depending on the results of further analyses. Otherwise, there is little flexibility in these numbers.

(5) Longitude of Apogees: This measure specifies where the peaks of the active arcs are located over the surface of the earth in coordinates relative to the rotating earth. For a Mean Motion of three, a satellite's ground track will pass through three apogee longitudes, spaced 120 degrees from each other in longitude. Therefore, for a given ground rack, specifying one Longitude of Apogee specifies the other two as well. For convenience, therefore, specifying the location of the active arcs in the region from 0 degrees West Longitude to 120 degrees West Longitude is sufficient to locate a ground track in any longitude orientation. This range may be termed the Americas Sector (the others may be termed the Eurasian Sector and the Pacific Sector). A given groundtrack may have any Longitude of Apogee in this 0-120 degree range.

Good coverage of important markets may be an important criterion for selecting the locations of the Longitudes of Apogees.

In each hemisphere, there can be two ground tracks, for a total of six apogees. The second ground track should have a Longitude of Apogee that places the active arcs between those of the first ground track, without crossing and maintaining a good separation from those of the first groundtrack. Once the Longitude of Apogee of the first ground track is established, the Longitude of Apogee of the second ground track may be placed 60 degrees in longitude from that in the first groundtrack, or slightly more or less, depending on desired coverage versus active arc separations.

(6) Active Arc Span: The active period of each VGSO satellite (*i.e.*, where the satellite is loitering more than 40 degrees above the equator) lasts approximately 4 Hours and 50 Minutes – 2 Hours and 24 Minutes (or 108 degrees of Mean Anomaly) to each side of apogee, plus a few additional minutes (2 or 3) per side for monitoring and switchover. The ratio of active satellites to total satellites per groundtrack per system determines this span. This choice derives from three active satellites and five total satellites per ground track.

(7) Mean Anomaly ("MA") at Epoch: This parameter is selected to place each satellite at an appropriate interval from its neighbor. The absolute number is not so important here as the relative MA. Absolute MA will determine the separations among satellites. Virtual Geo proposes to establish 0 degrees Mean Anomaly on January 5, 2005 as the index position in each ground track.[16]

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[16] At this time, it is not necessary to adopt a definitive standard for spacing between VGSO systems. The current number of applicants is small enough that even in the event that all decide to request VGSO licenses, wide spacings will be possible among the initial licensees. As in the development of GSO spacing criteria, the Commission should be able to determine over time what degree of separation between operational systems is optimal based on the number of systems licensed and the types of service they provide.

Basing licensing for Ku-band NGSO systems on the VGSO model will provide myriad technical and regulatory advantages, which are unique to this type of system architecture. Advantages achievable with the VGSO approach include a real opportunity to provide alternatives for satellite operators to offer service outside the GSO arc in the same spectrum now used for GSO Ku-band service, thereby relieving present spectrum congestion. This is particularly the case in those regions where look angles to the GSO arc are poor or where propagation delays associated with GSO use are undesirable.

The window in which virtual slots can be established for VGSO service is flexible. Although Virtual Geo is proposing that parameters be established for a spacing regime equivalent to the 2° standard used in the GSO arc, a wider separation could be adopted, at least initially. For example, if there is a desire to accommodate use of smaller Earth station dish sizes, the operational window for each system could be widened. The spacing tradeoffs involved are essentially identical to those that apply for GSO systems. Even at 4° spacing, the number of achievable co-frequency global VGSO systems is roughly three times the number of achievable co-frequency homogeneous low-Earth orbit systems.

b. Operational Benefits of VGSO Systems In Comparison to Non-VGSO NGSO Systems

Regardless of the spacing requirements that are chosen, a VGSO paradigm would foster multiple entry opportunities that cannot be achieved through the use of non-VGSO NGSO systems. Even a requirement for homogeneous non-VGSO NGSO systems across the band could not yield anywhere near the competitive opportunities achievable with the homogenous VGSO approach. In particular, if the Ku-band NGSO FSS spectrum were limited to use by non-VGSO NGSO systems, *and a single homogenous system design were selected*, the maximum number of co-frequency systems that could be accommodated for provision of global service would be on the order of four to five systems, far fewer than the 30 global-coverage systems that can be achieved using the VGSO model. Moreover, each of the handful of non-VGSO systems that could be implemented would have difficult coordination issues with existing GSO operators not present with respect to VGSO systems.

Nor are the benefits of regulatory simplicity confined to the initial stages of spectrum allotment and assignment. By establishing clear spectrum use rules at the outset and requiring licensees to adhere to standards that will maximize spectrum efficiency and eliminate the disruptive and repeated changes in the general scope, and even the precise location, of each licensee's spectrum use, the Commission will lessen the long-term regulatory oversight role that it will be required to undertake. Because the spectrum access and coordination rules for the GSO FSS are well established, licensees have in the great majority of instances been able to reach agreements on operational constraints through operator-to-operator coordination, with little Commission involvement. Appropriate decisions in this proceeding will provide a similar degree of certainty with respect to the Ku-band NGSO services. Indeed, because of the standardization of the VGSO orbital parameters, the Commission will be able to accept new applications for VGSO systems immediately after licensing of the first round applicants without opening up a protracted and cumbersome processing round, because it will be in a position to assign VGSO licenses quickly to qualified applicants. Similarly, FCC burdens with respect to international coordination will be lessened in an environment that allows standardized processing of system filings at the ITU.

By selecting an assignment solution that permits systems to operate across entire frequency bands, without selection of specific preferred spectrum assignments, the Commission can also avoid dealing with the difficult issues raised by the appropriateness of assigning spectrum blocks based on the launch of a single satellite. As noted above, launch of a single NGSO satellite, whether VGSO or non-VGSO, does not signal the achievement of meaningful operational capability, but simply an indication of first spectrum use. This is so because all NGSO systems inherently require multi-satellite arrays to provide actual service. Thus, making permanent assignments of spectrum based on the successful launch of just one spacecraft is suspect. But where spectrum assignments are based on larger allotments to compatible systems, no arbitrary frequency selection trigger need be selected.

Also eliminated is the concern that certain spectrum within particular sub-bands may be less desirable, *i.e.*, that there may not be true fungibility of spectrum use among different segments of the same sub-band.[17] By establishing conditions that allow multiple licensees to operate over broader frequency ranges, the Commission will minimize or eliminate the potential for a licensee to be relegated to a part of a band with less utility for provision of service.

Finally, establishment of rules to facilitate VGSO systems will produce substantial economic benefits for both the satellite industry and consumers. As in the case of GSO satellite systems, the standard technical parameters associated with use of the VGSO spectrum resource will permit the development of uniform equipment by manufacturers that can operate with different VGSO systems, as contrasted with the system-specific equipment required to account for the various system designs to be employed by the other proposed NGSO systems. Coupled with the reduced technical complexity of the VGSO satellites arising from the lack of any need to avoid in line interference with GSO satellites, these factors make VGSO service a less expensive option for service providers and users alike. Accordingly, overall implementation costs and risks will be comparable to those for GSOs, and will be dramatically lower than those of other types of global NGSO systems.

[17] *See NPRM*, FCC 01-134, slip op. at 7 (¶ 17).

2. The "Avoidance of In-Line Interference Events" Approach Is Overly Complex From An Operational Standpoint, And Is Economically and Technically Inefficient For Systems That Do Not Employ Satellite Diversity To Achieve GSO Protection Obligations.

In the *NPRM*, the Commission identifies a potential sharing option that is based upon the avoidance of in-line interference events.[18] Under this option, which the Commission indicates is premised on the necessary directivity of NGSO FSS antennas, separate NGSO satellite systems could share the same spectrum frequency and coverage so long as they avoid near in-line (and in-line) interference events.[19]

Virtual Geo has looked closely at this option, which is premised on a series of *ex parte* submissions made over the last few months by SkyBridge. This method would have merit if it did not require compulsory satellite diversity and uniform transmitter power from all operators. Although it may be useful in situations where all of the operational systems have the ability to employ the interference mitigation technique known as satellite diversity, it imposes extreme cost penalties and spectrum inefficiencies for systems that do not require satellite diversity.[20] For NGSO systems that do not include the capability to practice satellite diversity, the Commission's notion of using avoidance of in-line interference events as the basis for frequency assignments would be inequitable and completely infeasible in today's financial environment, as it could double system deployment costs for these systems while at the same time reducing their spectrum efficiency. As a practical matter, if both VGSO and non-VGSO

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18 *NPRM*, FCC 01-134, slip op. at 10-12 (¶¶ 28-36).

19 *Id.* at 10 (¶ 28). The Commission defines an in-line event as "an unintentional transmission in either direction between an earth station of one system and a satellite of another caused by physical alignment." *Id.* at 10 (¶ 29).

20 Circular-orbit NGSO systems, such as the low-Earth orbit architecture proposed by SkyBridge, incorporate the technique of satellite diversity, as this is the mechanism they would use to ensure that their satellites do not operate within the vicinity of the geostationary arc. This is contrasted with the orbital separation technique described above that is incorporated into Virtual Geo's VGSO model.

NGSO FSS systems were required to operate in common spectrum bands on this basis, phenomenal inefficiencies would result, including substantial reductions in power, the loss of system capacity and coverage area, and drastic constraints on total communications throughput. Even SkyBridge has acknowledged that its "earth-angle-based approach is feasible only if it is coupled with a uniform limitation on power levels of the NGSO FSS transmitters,"[21] and this is something that would not be possible for Virtual Geo's VGSO design to accommodate.

In the paragraphs that follow, Virtual Geo addresses the issues and questions raised by the Commission with respect to the "avoidance of in-line interference events" option. It concludes that for systems that are able to employ satellite diversity without unreasonable operational penalty, the option should be employed only to accommodate interested non-VGSO operators in the non-VGSO portions of the Ku-band NGSO FSS spectrum.

Within the category of in-line interference avoidance, the Commission offers two possible alternative techniques to achieve the intended result of preventing interfering transmissions in the main beam or side lobe of a co-frequency system. However, neither one of the approaches identified – satellite diversity or frequency isolation – is satisfactory for systems that are not designed to provide for dual satellite coverage.

a. Frequency Isolation Techniques

Given that in-line interference events among three or more systems simultaneously are very rare, and that simultaneous in-line events among all systems at once are all but non-existent, Virtual Geo believes that dividing spectrum at any time by any factor greater than two is excessively restrictive.[22] Accordingly, Virtual Geo can offer qualified support for the

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21 *NPRM*, FCC 01-134, slip op. at 12 (¶ 35).

22 *See* Appendix 1. As a threshold matter, Virtual Geo believes that the assumptions that the Commission suggests for the determination of the onset and duration of an in-line event are overly conservative, based on fears of multi-system in-line events that turn out to be overstated on closer examination. *See NPRM*, 01-134, slip op. at 11 (¶ 31). In simulations that Virtual Geo has conducted relative to the potential for in-line interference events

SkyBridge "Home Zone" approach, at least as a means of sharing among non-homogenous systems that are capable of employing the mitigation technique of satellite diversity. It is the best of several restrictive spectrum-sharing options that could be used for sharing solely among such systems.

The frequency and duration of Home Zone encounters are very sensitive to the size of the Home Zone. Total Home Zone encounter time per day increases roughly as the square of the Home Zone angle size. As a result, if such an approach were taken, Virtual Geo believes that the "Home Zone" angles applied should represent the actual characteristics of antennas in use, and not the arbitrarily large and over-penalizing +/-10° angle that has been presented by SkyBridge as an appropriate all-purpose guideline. This is particularly true in feeder link applications, where "Home Zones" may be appropriately defined using angles on the order of one degree rather than 10 degrees, and where triple in-line events would be virtually non-existent.[23] Home Zone angles of 5 to 10 degrees may be appropriate in user terminal bands and applications, but should also reflect actual designs rather than an arbitrarily conservative figure.[24]

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involving multiple NGSO operators, the probability of more than two systems experiencing a significant in-line interference event is so small – 0.01% of the time – that it can reasonably be ignored as a factor. *See* Appendix 1, Technical Statement. In most cases, it would only be necessary to divide spectrum in half to achieve adequate isolation, so that any additional provision for satellite diversity would be unnecessary.

23 Both the frequency and duration of identified interference events will increase as the size of the conical area in which in-line interference is defined as occurring ("interference cone") is itself increased. For this reason, Virtual Geo does not believe that adopting a benchmark in-line angle of ten degrees, as has been proposed by Skybridge (*see NPRM*, FCC 01-134, slip op. at 12 (¶ 35)), is appropriate for the Ku-band NGSO gateway environment. Typically much narrower beam masks will be in use, so that the ten-degree assumption would result in inefficient spectrum use by premising the defined interference cone on an overly pessimistic assumption. Coordination should instead be based upon a defined antenna mask corresponding to the antenna types and tracking methods that are actually in use. Indeed, in order to maintain interference to acceptable levels and facilitate coordination and sharing, it would be appropriate to establish a common mask among systems for at least the feeder link service.

24 Virtual Geo reserves judgment on the adoption of a mask for user links until it can conduct further study on the affect such an adoption would have on terminal design.

As Skybridge points out in its *ex parte* presentation on "Home Zones,"[25] any antenna angular discrimination used by the satellite can aid in further reducing the size of the interference cone. However, in feeder link applications, it is unlikely that the satellite will provide greater angular discrimination than will the ground station. In user terminal applications, the satellite may indeed provide greater angular discrimination than the user terminals, in which case it may be appropriate to use the narrower, satellite-determined interference cone for calculation purposes. Thus, while it may be appropriate to require similar masks among the feeder link stations of all the applicants, that may not be appropriate among their user terminals. Accordingly, the Commission should mandate emission masks that are tailored to actual antenna use, ensuring that interference power from the identified antennas falls within predictable angles so as to facilitate coordination based upon the relevant angles.

In addition, it must be noted that SkyBridge premises its suggestion of a 10 degree angle on "a uniform limitation on power levels of the NGSO FSS transmitters."[26] This constraint cannot be reconciled with the differing orbital architectures of the current NGSO FSS applicants. Maintaining uniform power levels for transmitting equipment could require systems operating at higher altitudes, such as VGSO or other highly-elliptical orbit systems, to employ larger satellite antennas, thereby substantially increasing satellite payload costs. At this point, there are not enough specifics associated with this proposal to quantify more precisely the degree of adverse impact on system deployment costs.

b. Satellite Diversity

The Commission should permit satellite operators to use diversity when it suits them as an alternative or supplement to any plan involving use of non-homogenous satellite

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[25] *See* SkyBridge L.L.C. *Ex Parte* Presentation in ET Dkt. No. 98-206, March 27, 2001.

[26] *See NPRM*, FCC 01-134, slip op. at 12 (¶ 35).

networks. Reliance on spacecraft diversity is a type of "Home Zone" scheme in which one network vacates the spectrum entirely during an in-line event by diverting traffic to another satellite, instead of using just half of the identified band, while the other operator continues to use the entire band. In effect, diversity is a special, non-symmetrical instance of frequency isolation that requires one system to vacate a spectrum band entirely during in-line encounters instead of splitting its use of the band with the other affected system. However, some systems and constellation designs lend themselves to a spectrum-vacating diversity approach more than others do. For systems designed without the need to access multiple satellites as a means of avoiding interference to the GSO arc, diversity operation would exact a much higher price in system performance and cost.[27] For this reason, it is appropriate to leave the decision to implement a spectrum-vacating diversity alternative or addition to the "Home Zone" spectrum split to the operators involved, to be determined during coordination. Satellite diversity is not an appropriate all-purpose mechanism for interference avoidance.

Fundamentally, imposing an affirmative satellite diversity requirement on all systems would be inappropriate. Because VGSO systems are reliant on single satellites lingering near the apogee of their elliptical orbital arc, the system architecture increases the potential duration of some types of near in-line interference events. Due to the wide separation between an active VGSO satellite and the GSO arc, however, there is no need for satellite diversity in order to provide service or to achieve compatibility with GSO operators. Accordingly, the costs

[27] Requiring systems not designed to employ satellite diversity techniques for interference mitigation to change to this approach would be a major additional cost burden for any operator. A significant investment in additional space-based hardware would be required, without any increase in system capacity, and costly and complex modifications to the VGSO ground segment, to permit Earth terminals designed for tracking one HLSSA to track additional HLSSAs, would also be necessary. The cost of a VGSO system could as much as double if interference events were to be eliminated entirely using this approach – *i.e.*, by doubling the number of satellites. Even lesser ameliorative steps would likely result in actual cost increases ranging from 25%-50% (*i.e.*, in excess of $1 billion) coupled with reductions in system capacity.

of implementing this means of in-line avoidance are substantially lower than for systems that require satellite diversity to achieve sharing with existing networks. At best, diversity methodology can reasonably be used by systems that desire to employ satellite diversity to mitigate around systems that do not use such a mechanism.[28]

The employment of satellite diversity among VGSO systems would exact a particularly large opportunity-cost penalty, in that VGSO systems would need to consume additional VGSO slots for the provision of diversity, slots which would otherwise be available for assignments to other systems within this or future proceedings. Moreover, whatever merits satellite diversity may have on paper, the ability of the methodology to respond to the vagaries of satellite systems under real-world operating conditions is suspect. As a practical matter, the logistics of any comprehensive mechanism to avoid in-line events are formidable, and would require far more than the typical degree of pre-coordination activity and operational cooperation among competing satellite operators. There is no workable mechanism available to manage data from the large number of spacecraft that would be operating in a multi-system NGSO FSS environment. While, at most times, a satellite operator should be able to obtain accurate ephemeris information for the satellites of his own system, even this is not necessarily true after a maneuver event. Indeed, the derivation of accurate satellite ephemera after a maneuver may require several days of satellite tracking. Maneuvers may be necessary from one to several times per month. As a result, there may be a significant percentage of time when ephemeris information is inaccurate, pending the development of updated data, and the ability to predict inter-system in-line events consequently would be impaired as well. For this reason, Virtual Geo

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28 *See* Working Party 4A Preliminary Draft New Recommendation, "Interference Mitigation Techniques to Facilitate Coordination between Non-Geostationary Fixed-Satellite Service Systems in Highly Elliptical Orbit and Non-Geostationary Fixed-Satellite Service Systems in Low- and Medium-Earth Orbits," Document 4A/TEMP/60 (Rev.1), at Annexes 1 and 2 (May 2001).

believes that it would be critical for the Commission to examine further the impact of satellite maneuvers on the availability of accurate ephemiris information for in-line interference coordination. In any case, the Commission should mandate that each licensed system publish up-to-date ephemeris information for all of its satellites in standard format for use in prediction of in-line interference events.

c. Suitability of GSO FSS Interference Rules For NGSO FSS Systems.

In conjunction with its discussion of the avoidance of in-line interference events option, the Commission also poses the question whether the coordination threshold that applies to GSO FSS inter-network interference should be applied to NGSO FSS systems.[29] Virtual Geo believes that geostationary interference limit rules must be applied to the NGSO environment with caution. Although it would not be inappropriate *per se* to set interference limits from one network into another on a network basis, two factors suggest that the interference limit specified among GSO networks may not be appropriate for NGSO networks as has been suggested by some applicants in this proceeding.

First, GSO networks are for the most part defined by a very small number of satellites, typically only one. Under such circumstances, satellite-to-network and network-to-network interference are very similar, if not the same. In addition, there are a large number of networks in the GSO environment, while networks in the NGSO environment are typically characterized by a large number of satellites per network, with the overall number of networks being relatively few. The relationship between satellites and networks is therefore very different in the two environments.

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29 *See NPRM*, FCC 01-134, slip op. at 11-12 (¶ 33).

Second, unlike the GSO environment, where neighboring satellites move slowly relative to each other and can be approximated by a static environment, the NGSO environment is much more dynamic. Interference from any one satellite into the ground station of another system will be transitory, and will vary significantly in level with time. Satellites with low angular separation to an operating link of another system will cause more interference to that system than satellites at wider separations, and the satellites responsible for the dominant in-line and close-by interference will be changing continually.

For these reasons, any translation from network-to-network interference to per-satellite interference must be approached with caution. For example, it would be inappropriate to modify a GSO interference threshold, such as the six percent (6%) increase in total system noise temperature by any one network into another, by dividing such a figure by the number of satellites in the interfering systems and limiting each satellite to such a reduced limit. Moreover, an increase in noise from one satellite of six percent into another lasting for a few minutes has a different, less significant interference impact than the same level of interference experienced on a continuous basis. Accordingly, any interference rule adopted should account for the transitory nature of one-on-one interference, and for the variation in interference contribution over time and among satellites within a network that results from varying separation angles.

The duration and spatial interference contributions appear to be intimately intertwined with antenna pattern masks, ultimate antenna off-axis rejection, and the specifics of the constellations and ground stations. The applicants define the latter factors, while the former may be established by regulation. Once set, simulation studies involving the proposed designs will determine the emission limits that would be sufficient to protect sharing systems. The distinctly unequal contributions to interference in angle and in time among satellites in a network should permit higher and less constraining interference emission limits from sharing constellations than would be possible if total interference were evenly allocated over all satellites within a system. Specifically, the six percent total network contribution will be dominated by only a few of the satellites of any other network. Should it be necessary to identify interference contribution limits from any one satellite into another system, per-satellite limits should be on the order of no less than one-half to one-quarter of the network limit cited above, to be further resolved by high-fidelity simulation studies.

3. Neither The "Flexible Band Segmentation" Option Nor The "Dynamic Band Segmentation" Option Advanced By The Commission Is Practicable For NGSO FSS Systems At Ku-Band.

The other two potential assignment proposals advanced by the Commission in its *NPRM* anticipate division of the band based on the same type of mechanism used in the recent 2 GHz MSS proceeding.[30] In each case, the available spectrum would be divided 1/n, with the distinction between the approaches being the point in time and the manner in which the value of "n" is determined. In the case of "Flexible Band Segmentation," the Commission would establish identical spectrum blocks in each band at the outset, dividing the six available sub-bands by the number of licensed systems. In doing so, the Commission would endeavor to make sure that each sub-band within the larger frequency ranges available for NGSO FSS service would be partitioned on terms that would allow each licensee adequate spectrum for each required use – user uplinks and downlinks, as well as gateway links in both directions. No specific channel assignments would be made at the time of licensing, instead each operator would choose its spectrum assignments only after it had launched its first satellite and commenced transmissions. Once a system became operational and had chosen specific bands in which to operate, it would be protected in those bands against any subsequent system launching

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30 *See The Establishment of Policies and Service Rules for the Mobile Satellite Service in the 2 GHz Band*, 15 FCC Rcd 16127, 16138-44 (2000).

satellites, and later comers would have to protect the licensed system in its designated bands. The first operational system would also have access to all other spectrum in the designated bands, but would be required to coordinate use in these bands with other users once one or more additional systems become operational.[31]

Under the "Dynamic Band Segmentation" approach, the same 1/n model would be used, but the spectrum would not be divided into blocks at the outset. Instead, the value of n could fluctuate, and the amount of spectrum available for exclusive use by each licensee would change dynamically, and somewhat unpredictably, as new systems become operational. The first authorized Ku-band NGSO network would have access to the entire spectrum in each of the sub-bands. Once a second system began operating a satellite, each band would be divided into two equal parts, and so on. For each re-division, the first system to launch would have the first selection of the portion of each band it desired to use.[32]

The fundamental problem with each of these approaches is that if all the licensed systems were to launch, the amount of spectrum that would then be available for each system would be insufficient to permit any operator to establish an economically viable business. Assuming that the spectrum division is 1/7, based on licensing of all systems currently applied for, the minimum quantity of spectrum that each would be guaranteed would be less than 100 MHz for user uplinks and less than 200 MHz for user downlinks – dramatically less than the quantity of usable spectrum sought by any one of the present applicants. Although the Commission notes in the *NPRM* "that it is possible, if not likely, that not all proposed systems will be implemented,"[33] it cannot count on this winnowing process to ensure that an adequate

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[31] *See NPRM*, FCC 01-134, slip op. at 8-9 (¶¶ 23-25).

[32] *See NPRM*, FCC 01-134, slip op. at 9 (¶¶ 26-27).

[33] *See NPRM*, FCC 01-134, slip op. at 7 (¶ 18).

amount of spectrum will be available to allow all licensees that do launch to achieve commercial viability. Indeed, the operational uncertainties created by the potential inadequacy of the spectrum that may ultimately be available to each licensee would pose a significant impediment to system operators seeking funding in the capital markets – which is likely to include all of the applicants now seeking authorizations. Establishing a frequency allotment mechanism that undermines the confidence of the financial community, particularly in the wake of recent high profile failures in the satellite industry, would likely slow the acceptance of new technology and delay the availability of the new broadband services that the Ku-band NGSO service providers can provide.[34] It is thus far from certain that the Commission is correct in its assessment that the Flexible Band Segmentation approach, for example, would provide "sufficient certainty" for authorized systems to proceed with implementation.[35]

Moreover, as the Commission notes in the *NPRM*, it cannot be certain that a sharing approach that relies on establishing spectrum blocks for each specific system licensed will be accepted and supported by other administrations. This factor would make coordination among U.S. and foreign licensed satellite networks under ITU Radio Regulation No. S9.12 unusually complicated. With respect to coordination with existing GSO service providers, the heterogeneity and fluidity of spectrum use entailed in the sub-band assignment processes the Commission has advanced will also complicate the ability to ensure protection of GSO satellites as envisioned by WRC-2000 and the *First Report & Order* in IB Docket No. 98-206.[36] Virtual Geo has long been a staunch advocate of the requirement that GSO FSS and BSS networks in the

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34 As SkyBridge noted in a recent *ex parte* filing "[b]ecause financial institutions are very sensitive to the consequences of an even unlikely default scenario, the economic impact of [1/n spectrum segmentation] should not be neglected." *See* SkyBridge LLC March 27, 2001 *Ex Parte* Letter, ET Dkt. No. 98-206, Attachment at 1.

35 *See NPRM*, FCC 01-134, slip op. at 9 (¶ 25).

36 *See Report & Order in ET Dkt. 98-206*, FCC 00-418, at ¶ 73 (released Dec. 8, 2000).

Ku-band frequencies must be protected by NGSO FSS systems, and a critical design feature of VGSO systems is the ability to provide this protection.

These same characteristics will also ensure that domestic coordination and regulatory oversight issues will remain prominent issues long after the issuance of licenses. For example, with operators guaranteed only a small portion of the available spectrum, the desire to make use of additional spectrum guaranteed or potentially available to other licensees will very likely lead to intense and contentious coordination discussions. Given the stakes, and the difficult technical tradeoffs that will be required – as well as their impact on capacity, and therefore, competitiveness – the licensees themselves are very likely to be unable to resolve disputes through conventional means, necessitating frequent and time-consuming intervention by the Commission. This too creates undesirable uncertainty for licensees and their investors.

Finally, the Commission's stated intent to establish spectrum rights as soon as an initial satellite is launched may not be appropriate for NGSO systems. The presumption that a system has entered into service when its initial satellite has reached its intended orbit and initiated transmission is the appropriate point to consider that the new network has been "brought into use" for ITU purposes. It does not follow, however, that this event is the point at which provision of service commences, because most or all of the NGSO systems before the Commission for consideration will require multiple satellites to be in place before meaningful service can be provided. As a frequency selection mechanism, therefore, it may be more appropriate to await the achievement of meaningful operational capability before making permanent assignments of spectrum, as this is actually the stage when service can begin.

B. The Commission Should Adopt Rules That Provide For Operation Of Homogeneous VGSO Constellations In Common Frequency Bands.

On the basis of technical merit and satisfaction of the overall public and national interests, a rule mandating that NGSO FSS Ku-band systems employ homogeneous constellations of the VGSO design would be most consistent with the public interest, convenience and necessity. As detailed above, the VGSO model will allow the Commission to establish the equivalent of a new frontier for Ku-band spectrum use – indeed, for FSS use generally – that allows many opportunities for provision of new service. Virtual Geo therefore urges the Commission to identify and designate a significant portion of the spectrum available for homogeneous VGSO systems. No system using VGSO technology in a shared environment would ever need to cut back its frequency use or waste valuable additional VGSO slots in order to deal with an encounter with a satellite of another VGSO system. Using slotting approaches not unlike those used in the GSO arc, crossings of active orbital arcs simply never occur.

1. Mandating The Use Of VGSO Technology Is Both Consistent With And Supportive Of U.S. And International Policies Concerning The Use And Protection Of Proprietary Technology.

In the *NPRM*, the Commission specifically solicits comment on "the impact Virtual Geo's patent [on VGSO parameters] would have on applicants who may desire to implement a system following the proposed parameters suggested for use by Virtual Geo."[37] The impact of Virtual Geo's patented technology is wholly positive with respect both to present applicants desiring to make use of VGSO architecture and to potential future applicants that may wish to implement future systems in the same spectrum.

The fact that U.S. patents protect particular aspects of the VGSO approach is not detrimental to other potential licensees because Virtual Geo is firmly committed to making the patented elements of its technology available, under reasonable terms and conditions that are free of unfair discrimination, to all operators interested in employing VGSO satellites. Moreover, to the extent that the Commission adopts Virtual Geo's band segmentation proposal, each current and future applicant will have the ability to determine which operational approach best suits it.

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[37] *See NPRM*, FCC 01-134, slip op. at 14 (¶ 42).

Should applicants choose to adopt the VGSO model, licensing of the necessary patented technology would be on a non-discriminatory basis pursuant to reasonable terms and conditions, pursuant to established Commission precedent and ITU practices.

The Commission has consistently found that it is appropriate to adopt technical requirements that employ patented technology, so long as the patent holder has committed to make the proprietary technology available on such a non-discriminatory basis, subject to fair and reasonable terms. For example, in the proceeding in which the Commission set technical standards for digital television ("DTV"), it found that applying such a straightforward non-discriminatory licensing policy toward patented technology, affording interested parties access on fair and reasonable terms, provided adequate safeguards for both consumer and competitive interests. For this reason, the Commission declined to assume any direct and continuing role in supervising the licensing of the subject technology. The Commission stated simply that its selection of a DTV system would be conditioned "on the proponent's commitment to reasonable and nondiscriminatory licensing of relevant patents."[38] In subsequently selecting a DTV standard, the FCC reiterated this condition, noting that because of patent holders' commitments, ". . . licensing of the patents for DTV technology will not be an impediment to the development and deployment of DTV products for broadcasters and consumers."[39] This same type of requirement was also imposed in the FCC's AM Stereo proceeding.[40] Virtual Geo's pledge to negotiate licenses with other applicants and parties on reasonable terms and conditions and on a

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[38] *Advanced Television Systems and Their Impact upon the Existing Television Broadcast Service*, 7 FCC Rcd 3340, 3358 (¶¶ 68-69) (1992).

[39] *Advanced Television Systems and Their Impact upon the Existing Television Broadcast Service*, 11 FCC Rcd 17771, 17794 (¶ 55) (1996).

[40] *Amendment of the Commission's Rules to Establish a Single AM Radio Stereophonic Transmitting Equipment Standard*, 8 FCC Rcd 8216, 8221 (¶ 29) (1993) ("As proposed in the Notice, we are conditioning the selection of Motorola's system as the AM stereo standard by requiring Motorola to license its patents to other parties under fair and reasonable terms").

non-discriminatory basis is also fully consistent with the ITU's Statement on Radiocommunication Sector Patent Policy, which governs its standard setting processes.[41]

Perhaps more significantly, adoption of a VGSO standard would affirmatively advance the constitutional mandate underlying the U.S. patent system "to promote the progress of science and useful arts, by securing for limited times to authors and inventors the exclusive right to their respective writings and discoveries."[42] A decision to reject use of a particular technology based on the existence of exclusive patent rights would stand this constitutional provision on its head and weaken the incentive for technical innovators to pursue new technological breakthroughs. Accordingly, Commission adoption of necessary technical standards subject to the requirements outlined above strikes the best balance of interests among all affected parties, providing access to publicly beneficial technology on terms that are advantageous for the patent holder, potential technology users, and satellite users alike.

Finally, under the VGSO hybrid assignment proposal presented here – unlike the circumstances before the Commission in the DTV and AM Stereo proceedings noted above – an applicant for NGSO FSS spectrum at Ku-band would not be required to use the VGSO parameters established. If the applicant decided not to license this technology, it would nonetheless be able to operate in the non-VGSO zones of the spectrum.

In sum, Virtual Geo's patents on some aspects of the VGSO technology will not have a negative impact on applicants that may desire to employ VGSO orbits. VGSO technology will be available to all interested applicants on fair and reasonable terms, and all will

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41 *See* Resolution ITU-R 1-3, Working Methods for the Radicommunication Assembly, The Radiocommunication Study Groups, and the Radiocommunication Advisory Group at Annex 1 (Mod. RA-2000).

42 U.S. Constitution, Article I, Section 8, Paragraph 8.

be able to benefit from the opportunities it affords. The adoption of Virtual Geo's proposal is thus fully consistent with U.S. and ITU patent policies.

2. Adoption of Rules Requiring Use of A Superior Technical Approach Is Consistent With Commission Precedent.

In this instance, the evident superiority of the VGSO approach would justify Commission imposition of a *requirement* that all spectrum identified for NGSO FSS use in the Ku-band frequencies be committed to VGSO use, rather than simply dividing the spectrum to ensure that all technical approaches advanced by the applicants may be pursued. The Commission has acknowledged in past proceedings that it may conclude that a particular technical approach provides superior public interest benefits, and should therefore be adopted in preference to other proffered solutions. For example, in the Big LEO proceeding, the Commission stated that one reason that it was adopting segmentation of the service uplink band was the fact that "the record did not support a finding that one architecture is superior to the other,"[43] suggesting strongly that an on-the-record determination that one technology would have greater public benefits would have led to a different result, *i.e.*, a decision to adopt the technology with demonstrably superior attributes as a standard for the bands being allocated.[44]

In light of the foregoing discussion, especially the enhanced spectrum efficiency and provision for pro-competitive multiple entry and future licensing opportunities made possible by VGSO operations, Virtual Geo strongly urges the Commission to conclude that this solution constitutes a superior technical solution for NGSO use of the Ku-Band. By ensuring that

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[43] *Amendment of the Commission's Rules to Establish Rules and Policies Pertaining to a Mobile Satellite Service in the 1610-1626.5/2483.5-2500 MHz Frequency Bands*, 9 FCC Rcd 5936, 5954 n.52 (1994).

[44] Virtual Geo notes that in the case of the Big LEO proceeding, a decision to adopt CDMA as an exclusive standard, and thereby exclude TDMA/FDMA technology, likely would not have led to the issuance of any more than the five authorizations that were otherwise granted pursuant to band segmentation, and would have left only minimal opportunities for future entry by other CDMA operators. By contrast, in this proceeding, adoption of the VGSO standard would not only permit all current applicants to be licensed to operate VGSO systems, but would leave numerous additional opportunities for future licensing – opportunities that would be reduced if the band were segmented, and eliminated entirely if some provision is not made for VGSO technology.

sufficient spectrum is available for provision of VGSO service, the Commission can meet all of the important public interest objectives that it has set in this proceeding – permitting each applicant to gain access to spectrum on fair terms, maximizing the spectrum available to operational systems to prevent spectrum warehousing, and providing both certainty to system licensees and the ability to coordinate shared use of spectrum by multiple operators.

3. Although the Commission Would Be Fully Justified In Mandating Use Of VGSO Technology In The Ku-Band, Virtual Geo Suggests A Possible Alternative Hybrid Approach To Accommodate All Current Applicants.

Despite the justification for mandating use of VGSO technology to maximize use of the Ku-band in the interest of providing opportunities for all, while minimizing the need for system redesigns, Virtual Geo believes that it would also be appropriate for the Commission to adopt a band segmentation plan that would set aside spectrum for non-homogenous NGSO satellite network designs, while also ensuring that a similar amount of spectrum is available for the more efficient and sharing-compatible VGSO service model. Virtual Geo is prepared to accept such a compromise, as outlined below, which would employ a hybrid assignment plan in the Ku-band frequencies available for NGSO FSS use.

As detailed in the spectrum allotment table on page 8 of these Comments, Virtual Geo proposes that all systems proposing to operate in the user uplink bands at 14.0-14.24 GHz (240 MHz) and the user downlink bands at 12.225-12.7 GHz (475 MHz) would be required to use VGSO constellations. For gateway links, VGSO satellite systems would operate uplinks at 12.75-12.96 GHz and 13.75-13.865 MHz (a total of 325 MHz) and downlinks at 10.7-11.175 GHz (475 MHz). These allotments are acceptable because approximately 715 MHz of dedicated user spectrum (240 MHz in the Earth-to-space direction and 475 MHz in the space-to-Earth direction) and 800 MHz of gateway spectrum (325 MHz in the Earth-to-space direction and 475

MHz in the space-to-Earth direction) are consistent with the minimum amounts of spectrum required to operate an economically viable VGSO system. As detailed above, the same spectrum can be reused by each of the homogeneous VGSO systems that is authorized, so long as the standardized VGSO licensing parameters are followed. As a result, spectrum will be used with maximum efficiency, and users will reap the benefits of greater competition and capacity availability.

The Virtual Geo plan contemplates a disparity in the spectrum assigned for uplinks and downlinks for both the VGSO and non-VGSO service and gateway bands. This disparity is appropriate given the practical differences in user demand for capacity in each direction. Most customers, particularly individual consumers, have asymmetrical needs for uplink and downlink capacity, requiring substantially more capacity on the latter link, *e.g.*, for Internet downloads. Accordingly, Virtual Geo believes that user needs can best be met through spectrum assignments that provide more downlink bandwidth.

The proposed plan leaves unassigned a small amount of the spectrum that is available in each band. The intent of leaving this portion of the spectrum out of the allotments is to provide a reserve from which the needs of systems that are able to make full use of their initial assignments can be met in the future. Accordingly, within each of the "growth zones," VGSO and non-VGSO systems would be required to coordinate with each other only after one or more systems had: (i) entered commercial service: and (ii) exhausted the available spectrum in its initial spectrum zones. Each system would enter into spectrum coordination/sharing arrangements to allow it to increase its access to spectrum, but only to the extent that it was able to demonstrate actual need for expanded spectrum usage.[45] While additional entry opportunities

[45] This type of approach is patterned after the existing North American GSO MSS coordination agreement governing spectrum use between AMSC and TMI.

would be expected to be available not only in the VGSO spectrum but potentially in the non-VGSO spectrum as well, the growth zone spectrum would not be considered available as separate bands for assignment to new applicants.

Under the approach proposed by Virtual Geo, all systems would nonetheless be licensed to operate across the entire user and gateway link spectrum that is allocated for NGSO use in the Ku-band. Thus, in the event that only satellites of the VGSO design are in operation at a given point in time, the operational system (or systems) could make use of the entire bands until a satellite of the non-VGSO NGSO variety is first brought into use. The converse would also be permitted, such that non-VGSO systems would be allowed to use the entire bands if no VGSO system were in operation.

C. A Hybrid Band Segmentation Approach Will Promote The Public Interest, Convenience, and Necessity.

Fundamentally, the hybrid spectrum allotment and assignment approach that Virtual Geo outlines above, while not optimal, is consistent with both the public interest and the essential goals and interests of each of the individual applicants. Not only does Virtual Geo's suggested approach enable all of the proposed systems to move forward as expeditiously as possible with system implementation, but the provision for accommodation of both VGSO architecture and non-VGSO architectures will permit all to proceed with a minimum of system redesign necessary. Moreover, by allotting equivalent spectrum to each type of system, the Commission will permit the marketplace to be the ultimate determinant of which applicants proceed with construction and offer service to the public.[46]

[46] As noted above, the unique sharing opportunities available in the distinct VGSO band will permit the FCC to open another early VGSO license processing round in the near future under the simpler and manageable VGSO sharing criteria.

In this regard, the approach suggested here is very similar to the compromise struck in the early 1990s in assigning spectrum for the CDMA and FDMA/TDMA systems in the Big LEO MSS.[47] In that case, if both CDMA and FDMA/TDMA technologies had been required to operate co-channel, co-frequency subject to coordination, it is very doubtful that either technology could have been implemented successfully due to intractable interference impediments to coordination of the two types of systems. The chief impediment to co-primary sharing was the spectrum access technique used by the various applicants. Here, the distinction of significance is the orbital configuration of the prospective licensees, as well as the number of potential co-frequency systems that could be accommodated using the different orbital configurations proposed.

Those applicants that are willing to embrace the VGSO architecture will also be able to secure the benefits available from this unique technology and the associated economies of scale that will derive from multiple operators using the same technical approach, including large scale production of standardized space segment and earth segment equipment for VGSO use. Manufacturers will be able to produce both space segment and earth segment equipment that can be used, with minor technical changes, by any number of licensed VGSO service providers. The availability of standardized equipment will also be of value to system end users, as the cost of Earth terminal equipment can be expected to be substantially lower where off-the-shelf units can be used to access multiple satellite systems, much as existing GSO earth stations are capable of use with virtually any licensed satellite within a given frequency band.

As detailed more fully above, establishing a separate VGSO band will also ease the complexities of an in-line avoidance approach that will need to be employed among co-

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[47] *See Amendment of the Commission's Rules to Establish Rules and Policies Pertaining to a Mobile Satellite Service in the 1610-1626.5/2483.5-2500 MHz Frequency Bands*, 9 FCC Rcd 5936 (1994).

frequency systems in the non-VGSO band segments. By limiting the use of the non-VGSO zones to systems that are able to avoid in-line interference events, and by eliminating the need for both non-VGSO and VGSO systems to consider in their core spectrum the extremely complex and costly sharing scenarios between these two fundamentally distinct approaches that would otherwise be involved, the operational burdens on all will be eased substantially. An added benefit of this outcome is the fact that the Commission itself will be substantially less likely to find itself drawn into protracted proceedings to determine the ability of different types of NGSO systems to coordinate their frequency use, to attempt to reconcile the inherent incompatibilities of these technologies, and/or to make findings that one technology is superior to another.

Unlike the full segmentation options, this hybrid approach provides all systems with a minimum amount of spectrum that is sufficient to enable operators to achieve economic viability. While this allotment may not be equivalent to the spectrum requests made by each of the applicants in their original applications, it nonetheless provides each prospective licensee with sufficient spectrum to fulfill its business plan. A system operator that cannot establish a viable system with nearly 500 MHz of user downlink spectrum is probably not going to be able to operate with sufficient spectrum efficiency to merit award of a license, and probably does not belong in the Ku-band NGSO FSS business in the first place.

Finally, accommodation of differing satellite network designs will reduce the risk that other administrations will adopt differing approaches to spectrum use in these bands that could complicate or prevent global introduction of service. By establishing two distinct zones, one for use by VGSO systems and one for use by systems employing satellite diversity, the Commission will set the stage for entry by a variety of service providers without creating substantial obstacles to implementation of service that would need to be overcome through international coordination.

D. Comments on Other Licensing Regulations

The Commission also seeks comment on a range of licensing and service rule proposals that build upon the rules currently applicable to satellite services. Virtual Geo supports adoption of many of the rules as proposed, and urges the modification of others in order to take full advantage of the spectrum sharing capabilities unique to the VGSO system design, or to permit an NGSO FSS operator, regardless of system design, to avoid burdensome regulations or respond to technological and marketplace changes during system implementation.

Virtual Geo addresses the Commission's proposed licensing and service rules in turn.

1. Earth Station Licensing

a. Licensing and Reporting Issues

The Commission has proposed blanket licensing for ubiquitously deployed user terminal earth stations in the 11.7-12.2 GHz and 12.2-12.7 GHz downlink bands and the 14.0-14.5 GHz uplink band.[48] Blanket licensing is the most practical and efficient means of regulating satellite service in these bands because it eliminates the administrative burdens associated with the filing and processing of duplicative applications. Accordingly, Virtual Geo fully supports the Commission's blanket licensing proposal.

Virtual Geo, however, questions the need for the Commission's related proposal to require an NGSO FSS licensee to file an annual report of the number of user terminal earth stations actually brought into service under its blanket licensing authority.[49] Other requirements

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48 *NPRM* at ¶ 46.

49 *Id.*

applicable to satellite licensees should provide the basic level of information needed by the Commission to monitor NGSO FSS system development. For example, the number of user terminal earth station units each licensee expects to bring into service must be included with its blanket license application. The benefit to be gained from imposing additional information reporting requirements would be outweighed by the administrative costs associated with the compilation, filing and evaluation of the reports. In addition, the Commission would also bear the burden of having to enforce the requirement. Virtual Geo, therefore, urges the Commission to reject its reporting requirement proposal. *See* Appendix 2.

b. Adoption of Technical Standards.

In the *NPRM*, the FCC recognizes that specifying an antenna reference pattern for NGSO FSS user terminal earth stations has the potential to facilitate sharing among NGSO FSS systems. However, the Commission states that it currently has little evidence to suggest that imposing additional limitations on NGSO FSS user earth stations would significantly improve sharing conditions.

In fact, there is significant evidence that defined antenna standards and off-axis EIRP limits can play a substantial role in enhancing spectrum sharing among systems employing homogeneous constellations. Specifically, studies submitted to ITU-R Working Party 4A, and reflected in a Preliminary Draft New Recommendation (4A/TEMP/77 (Rev. 1), have demonstrated that the use of uniform earth station antenna patterns, coupled with appropriate off-axis EIRP limits, will greatly enhance the ability of homogenous NGSO FSS systems to share spectrum. For this reason, it will be necessary for the Commission to specify an antenna reference pattern for NGSO FSS user terminal earth stations as a means of maximizing the utility of the homogenous constellation approach. Based on a minimum separation angle between satellites in different constellations (as seen from a given earth station location), the use of an antenna reference pattern and off-axis EIRP standard will be a substantial factor in determining the number of systems that can share the same frequency band. The use of a reference earth station antenna pattern coupled with off-axis EIRP limits will greatly enhance the ability of multiple homogeneous NGSO FSS systems to share the frequency band. By establishing such standards as baselines within the VGSO zone user terminal spectrum, the Commission will be able to increase substantially the number of future systems that can be introduced in the band.

Virtual Geo does not believe that the Commission is presently in a position to establish a definitive antenna reference pattern for Ku-Band NGSO systems. The Commission should nonetheless recognize as a policy matter that such a standard will be necessary. As an interim approach, it would be appropriate to employ a standard that will permit the use of earth stations in the range of 40 centimeters in diameter. A more definitive antenna pattern for NGSO operations can be addressed within industry groups, following further study. Similarly, the Commission should determine that off-axis EIRP limits will be necessary for VGSO Earth terminals, and commit to a future proceeding the derivation of the actual limits.

2. Service Rules

a. Coverage Requirements

The Commission has proposed to require that NGSO FSS systems be capable of providing service domestically on a continuous basis (*i.e.*, throughout the fifty United States, Puerto Rico, and the U.S. Virgin Islands) and internationally as far north as 70 degrees latitude and as far south as 55 degrees latitude for at least 75 percent of every 24-hour period – a proposal patterned after the coverage requirements applicable to the "Big LEO" MSS systems.[50] Although Virtual Geo's proposed Virgo system would provide essentially complete coverage of

[50] *See id.* at ¶ 51.

all of the world's oceans, it believes that the Commission should not establish global coverage requirements for VGSO systems, as the inherent versatility of the technology virtually guarantees global coverage by a variety of service providers pursuing different service plans. Virtual Geo urges the Commission to acknowledge the real world capabilities and uses of VGSO FSS.[51] Operators of VGSO systems should be permitted to exercise their business and technical judgment in determining the benefits of global coverage. *See* Appendix 2, § 25.146(i).

On the same topic, the Commission has asked whether the rationale for imposing a global coverage requirement on the "Big LEO" MSS licensees – namely, to ensure efficient global use of the limited spectrum resource – applies to the NGSO FSS.[52] Virtual Geo believes that it does to the extent that the Commission should act to promote the availability of Ku-band NGSO services to all parts of the world. In doing so, however, the Commission should take into account the technological differences between the two services and recognize that these differences allow for varying means of achieving this important goal. For example, in significant part through use of the VGSO spectrum use model, there will be substantially more opportunities to provide NGSO FSS service in the Ku-band than there were for provision of MSS in either the 1.6/2.4 GHz bands or the 2 GHz bands due to the relatively large number of VGSO slots available. While each VGSO satellite alternates among three HLSSAs, the slotting capability offered by VGSO technology will allow individual operators to target specific markets through optimization of service for hemispheric, regional or even national coverage, yet global coverage can still be effected by multiple licensees pursuing different target markets using satellites they share, much as individual GSO satellites may be geared toward U.S. domestic, European or

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51 Coverage requirements over water, while applicable to the MSS, make little sense when applied to the FSS given how the service's fixed nature essentially restricts communications to earth station terminals on land. Indeed, FSS on water *is* MSS.

52 *See id.*

trans-Atlantic service – with the added twist of periodically exchanging satellites with each other. To facilitate regionally tailored service using shared VGSO satellites, a VGSO licensing policy could assign individual HLSSAs either on a contingent basis, or possibly through the "reservation" of one or more HLSSAs, for possible groupings of complementary regional or national systems as licenses for each region issue relative to the shared satellite.

b. Financial Qualifications.

Virtual Geo strongly supports the Commission's tentative conclusion that an encompassing spectrum sharing plan moots the need for a financial qualifications standard.[53] The historic rationale for the use of a financial requirement– *i.e.*, to prevent underfinanced applicants from depriving fully capitalized applicants from using the scarce spectrum resource – serves no meaningful purpose where, as in the case of the Ku-band NGSO FSS, the spectrum needs of all potential applicants can be accommodated.

In any event, financial qualifications are not an accurate predictor of whether a company will proceed with construction of a global satellite network. In the past, small entrepreneurial ventures have proven successful in attracting necessary capital to provide new satellite service, while well-established companies with ample internal resources have abandoned efforts to construct new networks. Given this history, requiring an applicant to "earmark" funds[54] at the time of licensing is a meaningless (and arguably punitive) requirement as even large corporations, when undertaking a project as capital-intensive as a multiple satellite network, generally look to outside sources of funding through public debt, equity offerings or partner recruitment. *See* Appendix 2, § 25.146(n).

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53 *See id.* at ¶ 52.

54 *See NPRM*, FCC 01-134, slip op. at 17 (¶ 53).

The Commission has stated that it may impose a strict financial qualifications standard should it become apparent that the allocated spectrum cannot accommodate all potential applicants.[55] Although Virtual Geo agrees that the Commission should retain the option of imposing such a standard under certain circumstances, it cautions the agency against applying the standard reflexively and without regard to the various sharing capabilities made possible by the band plan eventually adopted. If mutual exclusivity exists in the non-VGSO portion of Virtual Geo's proposed band plan, but not in the VGSO portion, a financial qualifications standard should apply only to the non-VGSO licensees. NGSO FSS operators employing the more efficient VGSO architecture should not be penalized for the less efficient constellation designs used by other licensees in the Ku-band. In fact, under the VGSO architecture, there is no mutual exclusivity whatsoever, at least not before several dozen global systems are deployed across the entire band.

c. System Implementation Milestones.

In lieu of imposing a financial qualification standard, the Commission should focus on adopting constructive and enforceable implementation milestones, which history has shown to be a valid and reasonable means of achieving the policy objectives underlying a financial demonstration. Unfortunately, the full system milestone showing proposed by the Commission in the *NPRM* is overly burdensome and comes at the price of restricting an operator's flexibility to make mid-stream adjustments to its business model during implementation.

The Commission has specifically proposed that NGSO FSS licensees be required to enter into a non-contingent satellite manufacturing contract for the system within one year of authorization, complete critical design review within two years of authorization, begin physical

[55] *See id.*

construction of all satellites in the system within two and a half years of authorization, and complete construction and launch of the first two satellites within three and a half years of grant.[56] In Virtual Geo's estimation, a better, less onerous approach would require NGSO FSS licensees simply to: (1) enter into a non-contingent satellite manufacturing contract covering the entire proposed system within 18 months of license grant (rather than within 12 months as proposed by the Commission)[57]; and (2) bring into use its full constellation of satellites within six years of license grant (as the Commission has proposed). *See* Appendix 2, § 25.146(l). These streamlined milestones will ensure timely system commencement and completion (the ultimate goal of any implementation timetable) without sacrificing the flexibility that operators need to respond to unforeseen technical or marketplace changes that often occur during system implementation.

Similarly, the milestone schedule adopted by the Commission should be flexible enough to allow licensees to phase in their network over time. The demand for satellite service is fluid, and system requirements designed to meet today's customer needs may require modification just a few years from now. Allowing licensees to phase in service would permit them to change course in response to unexpected market conditions, conserving capital where necessary to weather downturns in the financing environment and demand for new service. By entertaining reasonable requests for modification of milestone deadlines, the Commission would allow licensees to respond more effectively to the changing marketplace. The Commission's goal should be ensuring that an appropriate level of service is being offered to the public consistent with market demand, not the reflexive adherence to a pre-established timetable for

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56 *NPRM*, FCC 01-134, slip op. at 18 (¶ 56).

57 This contract should contain milestone and payment schedules for system build-out but not include a clause allowing for termination of the contract for convenience.

system build-out. Indeed, this approach is particularly appropriate with respect to services employing the first generation of new technology.[58]

Virtual Geo is aware that, in the "Big LEO" proceeding, the Commission rejected the request to adopt flexible milestones, which would have permitted implementation of satellite systems in stages.[59] That decision, however, is factually distinct from the current circumstance in that the "Big LEO" service was the world's first commercial low-earth orbit satellite service capable of providing voice and data MSS on a global basis, and the LEO and MEO systems proposed required a full constellation of satellites in order to meet this global coverage goal. Under these particular circumstances, the Commission rejected the "phase-in" of the "Big LEO" milestones out of concern that expeditious provision of global service could not be achieved by partially constructed networks.[60]

In contrast, VGSO systems in the Ku-band can be implemented in stages without sacrificing coverage capability. Unlike non-VGSO systems, most of which would have significant gaps in coverage without a full complement of satellites, Virtual Geo's model will allow full service at reduced capacity over much of the Northern Hemisphere with just one third (5) of the anticipated satellites in place. This aspect of the VGSO technology is an asset in that it will allow operators to roll out service on an incremental basis without having to finance an entire constellation before the first penny of revenue is earned. This feature is certain to make this service model more attractive to potential investors, and will allow for the more rapid

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58 *See United States Satellite Broadcasting, Inc.*, 3 FCC Rcd 6858, 6860 (¶ 14) (1988) (rejecting strict adherence to "a pre-established timetable set without the benefit of experience" with respect to first generation DBS system).

59 *See Amendment of the Commission's Rules to Establish Rules and Policies Pertaining to a Mobile Satellite Service in the 1610-1626.5/2483.5-2500 MHz Frequency Bands*, 9 FCC Rcd 5936, 6009 (1994).

60 *See id.*

introduction of new advanced broadband service to the public, thereby increasing competition to existing satellite and terrestrial services.[61]

Moreover, permitting the implementation of VGSO service in stages would not contravene the policy objectives of facilitating development of service and the efficient use of the limited available spectrum that underlie the Commission's milestone policies. Because VGSO systems are capable of sharing spectrum with both GSO existing users and other networks employing the same VGSO architecture, the failure of one licensee to implement service in accordance with its license would not result in idle spectrum. New operators can continue to be authorized upon application without reclaiming spectrum from previously licensed operators.[62]

d. System License and License Term.

The Commission has proposed the authorization of NGSO FSS licensees under a single blanket license for the construction, launch and operation of technically identical space stations and replacements.[63] Virtual Geo supports this approach, which mirrors the regulatory treatment historically accorded NGSO systems. Virtual Geo also backs the proposal to make license terms run for 10 years from the date on which the first space station in the system begins transmitting and receiving radio signals.[64]

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61 *See NPRM* at ¶ 2.

62 Regardless of the implementation milestones eventually adopted by the Commission, Virtual Geo supports the proposed requirement that operators certify compliance – or the filing of a disclosure of non-compliance -- within 10 days following a milestone specified in the system authorization.

63 *See NPRM* at ¶ 54. Virtual Geo supports the Commission's proposal to require that all replacement satellite applications be filed no earlier than three months prior to, and no later than one month after, the end of the eighth year of the existing license term.

64 *See id.* Here, it makes sense to use the commencement of transmission date, rather than the commencement of service date, as the transmissions require a license, and are objectively easier to identify than commencement of service.

e. Regulatory Classification.

The Commission tentatively concludes that each of the NGSO FSS applicants should be treated as non-common carriers.[65] Virtual Geo itself has requested treatment as a non-common carrier, and fully supports the Commission's conclusion. The Commission has for many years given satellite service providers the option of operating on a common carrier or private carrier basis, and there has been no change of circumstances that would support a departure from this well-established policy.

f. Reporting Requirements.

In the NPRM, the Commission proposed to apply to the NGSO FSS the reporting requirements applicable to FSS systems under Part 25 of the Commission's rules.[66] Under these requirements, FSS licensees currently must file an annual report with the Commission describing, *inter alia*, the status of satellite construction and anticipated launch dates (including any major delays or problems encountered) and the use made of each satellite in orbit.[67] The Commission's proposal, however, would eliminate the existing requirement to report unscheduled satellite outages.[68]

Virtual Geo opposes the breadth of the proposed reporting requirements. Annual reports may serve the limited purpose of providing the Commission with the means of monitoring the construction of a satellite system, but, as noted in the discussion on earth station licensing above, the information necessary to track spectrum use once construction is completed should be available to the Commission by means less burdensome than that associated with the

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65 *See id.* at ¶ 55.

66 *See id.* at ¶ 58.

67 *See* 47 C.F.R. § 25.210(l).

68 *See NPRM* at ¶ 58.

filing of the proposed annual report. While the reporting requirements cited by the Commission may have been necessary in the early days of development of the satellite industry, when each transponder constituted a significant percentage of the total available space segment capacity, it is not clear that reporting of this data continues to serve any useful purpose.

On the other hand, Virtual Geo fully supports the Commission's decision to eliminate the unscheduled-outage reporting requirement. That requirement, designed to ensure that satellite spectrum resources are not warehoused in orbit, is unnecessary given the Commission's recognition that satellite spectrum will be available to all potential NGSO FSS applicants.

g. Compliance with aggregate $EPFD_{down}$ limits

In the *NPRM*, the Commission decided to defer mandating the requirement that NGSO FSS licensees demonstrate compliance with the aggregate $EPFD_{down}$ limits, pending the establishment of an accurate methodology to measure aggregate levels.[69] To support its decision, the Commission cited the many regulatory difficulties associated with verifying aggregate limit compliance, as well as the lack of urgency for the adoption of such limits.[70]

The Commission's reasoning notwithstanding, Virtual Geo remains concerned that continued deferral of compliance with aggregate $EPFD_{down}$ limits could endanger existing GSO systems operating in the Ku-band if a large number of co-frequency circular orbit NGSOs emerge following licensing. It bears repeating that this risk could be avoided with the Commission's adoption of the VGSO system design, because its 40+ degree separation from the GSO arc will not contribute meaningfully to the aggregate $EPFD_{down}$ experienced by GSO systems.

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69 *See id.* at ¶ 60.

70 *See id.* at ¶ 59.

The ITU is currently developing methodologies to calculate the aggregate $EPFD_{down}$ produced by all NGSO FSS systems and that the United States is heavily involved in this development. However, the lack of a methodology to calculate the aggregate $EPFD_{down}$ produced by all NGSO FSS systems should not hold up the development and licensing of NGSO FSS systems – such as VGSO systems – that do not implicate the concerns regarding aggregate epfd limits that the ITU-R is now addressing.

Once the proper methodology is developed, the results of an analysis using the VGSO model will show that this type of system (designed such that there is always a large separation with respect to the GSO arc) will only add to the long-term aggregate $EPFD_{down}$ and will not significantly increase the aggregate $EPFD_{down}$. In the case of homogenous constellations of the VGSO design, the ITU has studied the maximum aggregate $EPFD_{down}$ produced by these types of systems and a preliminary methodology is contained in PDNR [4A/TEMP/77 (Rev. 1) - Annex 2]. An input contribution from the U.S. to ITU-R WP 4A has shown that "under pessimistic assumptions for the GSO receive antenna off-axis gains, at least 17 such systems could operate and protect all GSO antenna sizes. Using more realistic assumptions, the resultant number of VGSO-type systems that could operate and protect all GSO antenna sizes is 31.

Regardless of their system architecture, however, non-VGSO NGSOs should have their authorizations conditioned on compliance with the aggregate $EPFD_{down}$ limits, and to a reexamination of these limits, as necessary, based on whatever methodology is ultimately adopted.

h. International Coordination.

The Commission has requested comment on the extent to which the proposed NGSO FSS spectrum sharing options could achieve compatibility with the spectrum sharing planning and satellite system licensing processes in other countries. In this regard, Virtual Geo reminds the Commission that VGSO-type NGSO architecture allows multiple GSO, NGSO and terrestrial networks to share spectrum to a degree not possible with non-VGSO NGSO systems. Moreover, as there are no "bad" orbital locations in the VGSO arcs (because all locations are essentially equal), the adoption of the VGSO design by the Commission would remove much of the burden associated with coordination on satellite system operators and administrations.

Virtual Geo supports the adoption of proposed Section 25.146(j) (*see* Appendix 2, § 25.146(k)), which would prohibit certain exclusive agreements that give the NGSO FSS licensees benefits overseas that are denied to other U.S. licensees. Restricting exclusive agreements promotes competition and advances the creation of a seamless global communications network. Virtual Geo also urges the Commission to attempt to implement internationally the VGSO/non-VGSO band plan proposed in these comments. The numerous advantages unique to Virtual Geo's proposed plan, as discussed above, would translate to international markets as well. In addition, implementation of the Virtual Geo plan would further the Commission's policy of pursuing international coordination for U.S.-licensed satellite systems consistent with its domestic frequency band plans, thereby avoiding the risk of substantial delay in the roll out of service by the NGSO FSS licensees.

III. CONCLUSION

Based on the foregoing discussion, Virtual Geo urges the Commission to adopt a requirement for use of VGSO-type NGSO FSS systems in the Ku-band, if not over the entire spectrum allocated for this service, then in accordance with the equitable band segmentation plan that is proposed herein. As established in prior proceedings, the VGSO model is fully compatible with the existing operations of Ku-band GSO FSS satellite operators, and thus will not constrain future growth of this service. Moreover, a requirement to use VGSO architecture will promote salutary competition among Ku-band NGSO FSS systems to a degree far greater than provided for by any other NGSO FSS system approach, offering additional entry opportunities not only to interested applicants in the current proceeding but also to potential future service providers, including those unable to gain access to the already saturated C-band and Ku-band GSO arcs. By ensuring that sufficient spectrum is available for provision of VGSO service, the Commission can meet all three of the primary objectives it has set in this proceeding – (1) permitting all applicants to have equal access to spectrum, (2) maximizing the spectrum that is available to operational systems to prevent spectrum warehousing, and (3) providing both certainty to system licensees and the ability to coordinate shared use of spectrum by multiple operators.

Respectfully submitted,

VIRTUAL GEOSATELLITE LLC

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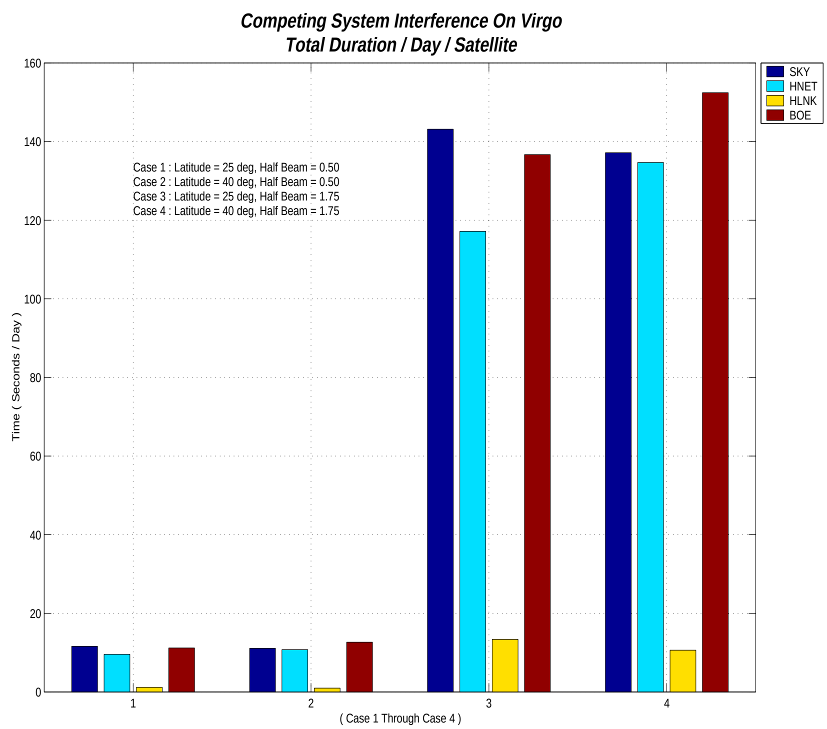
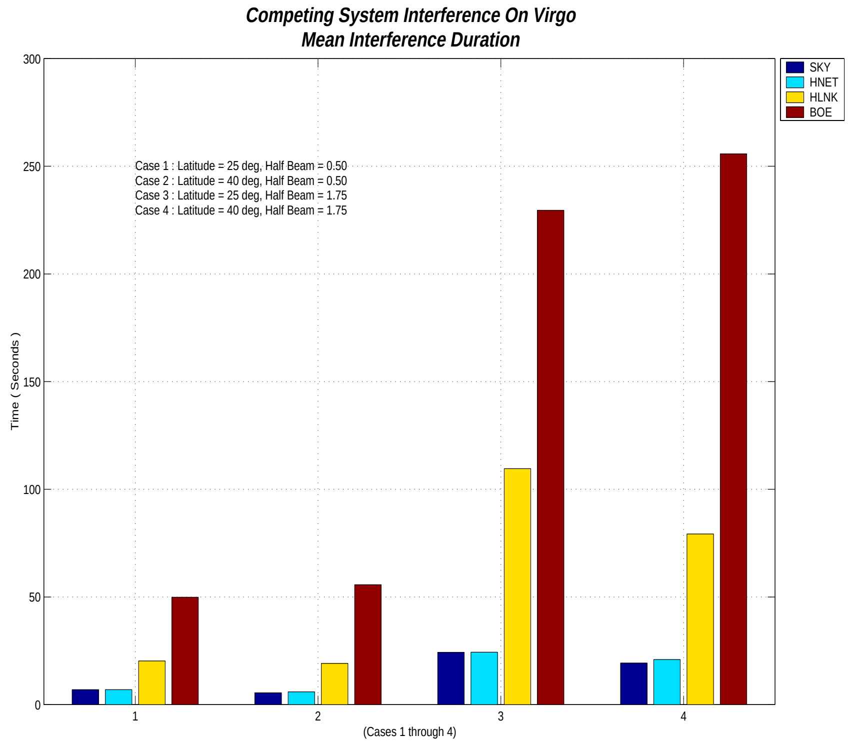
APPENDIX 1

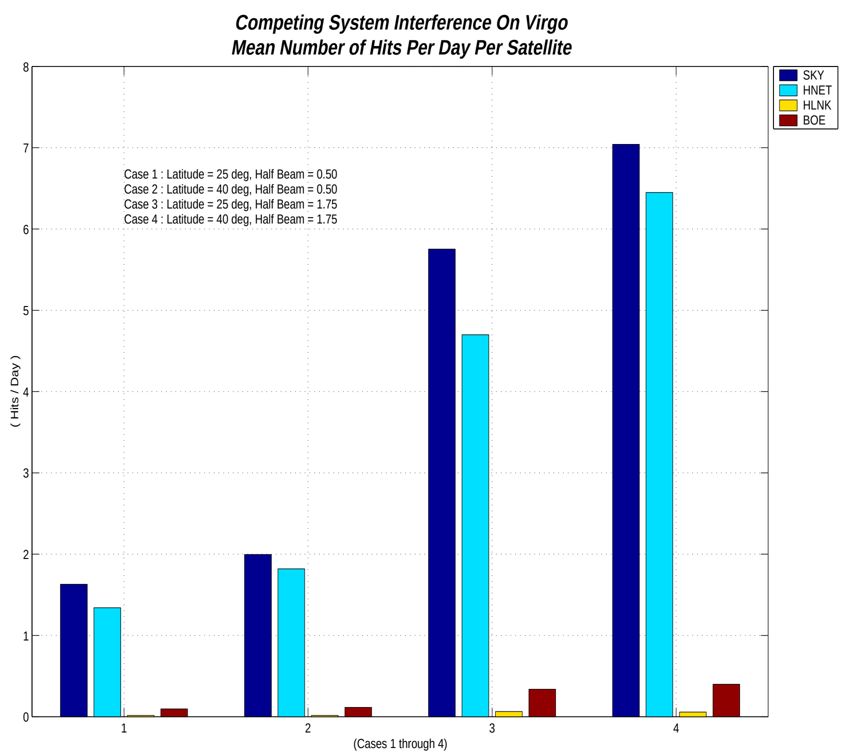
Interference Characterization Among Non-Homogeneous NGSO Systems: The Likelihood of In-Line Interference Events in a Multi-System Environment

Interference studies undertaken by Virtual Geosatellite, LLC ("Virtual Geo") have demonstrated that the degree of interference from one system into another depends on the following factors: (1) the angular separation between the satellites in use in the two systems, (2) the rapidity with which the angle changes, (3) the ground station antenna beam width, (4) the ground station off-axis eirp reduction, (5) the ground station location, (6) the degree of frequency isolation between the two systems, and (7) the relative power flux density levels employed by the two systems in the link in question. Geometrically, interference can arise when a foreign system wanders into the main beam axis of a system, or when off-axis radiated powers of any system are large enough to overcome the angular discrimination of the antenna systems of another system or its filtering.

Virtual Geo has investigated the likelihood and duration of in-line, co-frequency interference events, and has found that in an environment of only 3 to 4 systems sharing the same spectrum, the frequency and duration of in-line interference is large enough to have a significant adverse impact on the perceived value and marketability of the data transport services intended for the system (predominantly internet access and backbone services). This is true using even relatively narrow cones within which interference might be deemed possible. The following figures illustrate some of the study's results.




Competing System Interference On Virgo
Mean Interference Duration
Time (Seconds)
300
250
200
150
100
50
0
1
2
3
4
(Cases 1 through 4)
SKY
HNET
HLNK
BOE
Case 1 : Latitude = 25 deg, Half Beam = 0.50
Case 2 : Latitude = 40 deg, Half Beam = 0.50
Case 3 : Latitude = 25 deg, Half Beam = 1.75
Case 4 : Latitude = 40 deg, Half Beam = 1.75


Competing System Interference On Virgo
Mean Number of Hits Per Day Per Satellite
(Hits / Day)
8
7
6
5
4
3
2
1
0
1
2
3
4
(Cases 1 through 4)
SKY
HNET
HLNK
BOE
Case 1 : Latitude = 25 deg, Half Beam = 0.50
Case 2 : Latitude = 40 deg, Half Beam = 0.50
Case 3 : Latitude = 25 deg, Half Beam = 1.75
Case 4 : Latitude = 40 deg, Half Beam = 1.75

Specifically, by way of scaling the problem, Virtual Geo defined two interference scenarios, a gateway interference scenario, and a user terminal interference scenario, differing by the angular width of the main-beam interference cone. The gateway in-line interference study used an interference cone half-angle (edge to center) of 0.5 degrees, while the user terminals in-line interference study used an interference cone half-angle of 1.75 degrees. Virtual Geo found that in the gateway in-line interference scenario, total interference per day into the defined interference cone averaged 10 seconds per interfering system for most other systems (except one, which averaged 2-3 seconds per day). In the user terminal case, the study found that interference averaged a fairly consistent 120 to 150 seconds per day per system (except again for one system, averaging 15 seconds per day). In an environment of four systems sharing the same spectrum, therefore, Virtual Geo's proposed Virgo system would suffer as much as 40 seconds per day of outage to its feeder links and 8 to 10 minutes of outage per day over satellite-to-user terminal links. Interference to the feeder link represented a link availability of 0.9993, while the interference to the user links represents an average availability of 0.993. In each case, in-line interference alone causes the system to fall short of its modest designed availabilities of at least 0.9999 and 0.999 for gateway and user terminal links respectively.

However, the above study assumed that in-line interference only occurred when a foreign satellite fell within the main beam cone of an earth station-to-satellite link. Typically, the first sidelobes of well-designed antennas will fall in the range of 25 decibels below peak gain, plus or minus a few dB. Assuming the power flux density of the foreign system is equivalent to the desired system's level, this amount of sidelobe suppression will nevertheless result in interference levels alone that are at or above the noise floor, resulting in a significant change in link performance. Hence it appears to be necessary to include at least the first sidelobe in determining what constitutes the angular size of an in-line interference cone. In-line interference statistics, as can be seen above, are very sensitive to the size of the interference cone. Enlarging the angular size of an interference cone around a link lengthens the transit time of an interfering satellite through the cone, lengthening the corresponding interference event, and increases the number of near miss trajectories that intersect the cone, increasing the frequency of interference events. Hence the total amount of in-line interference to a system per day increases roughly as the square of the size of the interference cone, assuming uniform distributions, which can also be seen in the statistics reported above. SkyBridge's reported interference simulation results also show a marked sensitivity to interference cone angle.

If it is necessary to protect the main beam and first sidelobe of earth stations, the size of the interference cone half-angle doubles. In this case the interference statistics above become, for five total systems, as much as 160 seconds per day of interference per gateway terminal, and 2/3 hour per day per user terminal during which performance is either degraded (sidelobe interference) or denied (main beam interference). These are clearly unacceptable numbers. Also, without acceptable suppression of far sidelobe eirp from ground station antennas so as to ensure these far-off-axis signals do not become an appreciable interference source, system performance between in-line interfering events will degrade, as it will if an assumption of balance in spectral flux density is not valid, in the case of the weaker system.

On the other hand, Virtual Geo's interference study did not find a single instance of three-system simultaneous in-line interference in a month of time simulating five systems simultaneously. Intuitively, one would expect a triple interference event to have a probability equal to the product of the probabilities of a two-system in-line event for the two other systems involved (assuming no correlation in orbital behavior between them). For the results above, the probability of user terminal in-line interference amounted to around .007 among most of the systems. A triple system interference event should have a probability of around $(0.007)^2$ or 0.000049, yielding a user terminal availability due to triple system interference of 0.99995 or an outage of 10 minutes per year. Gateway availability in the corresponding case is much better at around 0.9999995. Increasing the interference cone to include the first sidelobe yields availabilities four times worse, or around 0.9998 for the user terminal and 0.999998, both acceptable numbers in our judgment.

Hence, Virtual Geo believes that, for its purposes, and given interference cones defined as above, any interference protection scheme need only protect against two-satellite in-line interference events, provided that adequate statistical independence exists in the spatial behavior of the various constellation designs, and provided that the links in question use reasonably narrow beam masks as defined above. Triple interference events may become significant for terminals using wide beamwidths, which should only apply to certain low-gain user terminal types.

TECHNICAL CERTIFICATE

I, John W. Brosius, III, hereby certify, under penalty of perjury, that I am the technically qualified person responsible for the preparation of the technical discussion contained in the foregoing "Comments of Virtual Geosatellite LLC," and in the Technical Appendix thereto, and that this information is true and correct to the best of my knowledge and belief.

July 6, 2001

By: /s/ John W. Brosius, III
John W. Brosius, III
Virtual Geosatellite LLC

<u>APPENDIX 2</u>

Below, Virtual Geo sets forth its suggested changes to the rules that the Commission has proposed in the *NPRM* in IB Docket No. 01-96. Additional text is shown as <u>underlined</u>, deleted text is indicated by ~~strikethrough.~~

PART 25-SATELLITE COMMUNICATIONS

The authority citation for Part 25 continues to read as follows:

AUTHORITY: 47 U.S.C. 701-744. Interprets or applies Sections 4, 301, 302, 303; 307, 309 and 332 of the Communications Act, as amended, 47 U.S.C. Sections 154, 301, 302, 303, 307, 309 and 332, unless otherwise noted.

<u>1. Section 25.103 is amended by adding a new paragraph (g) to read as follows:</u>

<u>§ 25.103 Definitions</u>

<u>* * * * *</u>

<u>(g) *Virtual Geostationary Satellite Orbit (VGSO) System/Network*: A non-geostationary satellite system or network in which satellites transmit or retransmit radiocommunication signals while within a defined Virtual Geostationary Space. The Virtual Geostationary Space is a set of high latitude stationary slotted arcs (HLSSA) over the Earth in Earth-centered, Earth-fixed coordinates in which a number of satellites may operate simultaneously while maintaining a minimum specified angular separation from each other (defining a "slot" size) at all times. Virtual Geostationary Space is itself synchronous with the rotation of the Earth, and always separated from the geostationary arc by at least 40°.</u>

<u>Each satellite operating in a VGSO system or network must move in a subgeosynchronous orbit characterized by the parameters (defined at a common epoch time for all systems or networks) in Table 1 below:</u>

<u>Table 1</u>

<u>1. Mean Motion</u>	<u>3 (yielding 3 active arcs equally spaced in longitude around the Earth)</u>
<u>2. Inclination:</u>	<u>63.435° to ensure fixed apogees in a posigrade orbit</u>
<u>3. Eccentricity:</u>	<u>0.63-0.66</u>
<u>4. Argument of perigee:</u>	<u>270° for Northern arcs, and 90° for Southern arcs</u>
<u>5. Longitude of Apogees:</u>	<u>Fixed for all satellites to avoid crossings of HLSSAs; adjacent ground tracks must be separated by an angle of nominal value of approximately 60° (see Note)</u>

<u>6. Active Arc Span:</u>	<u>Nominal 2 hours and 24 minutes to each side of apogee plus *x* minutes for housekeeping and handover at activation and deactivation on each end, for a total of 4 hours and 48 minutes plus 2*x* minutes duration in the active arc (*x* = 2 to 3 minutes).</u>
<u>7. Mean Anomaly at Epoch:</u>	<u>As needed to achieve minimum desired active arc angular spacing</u>

<u>Note: All VGSO satellites following Northern Hemisphere ground tracks must use common HLSSAs, and all VGSO satellites following Southern Hemisphere ground tracks must use common HLSSAs. For example with a baseline ground track that has a longitude of apogee at 65° West (East Coast), the next ground track would have a longitude of apogee at approximately 125° West (West Coast) and so on in order to prevent crossing of active arcs.</u>

2. Section 25.115 is amended by adding a new paragraph (f) to read as follows:

§ 25.115 Application for earth station authorizations.

* * * * *

(f) User transceivers in the non-geostationary satellite orbit fixed-satellite service (NGSO FSS) service in the 11.7-12.2 GHz, 12.2-12.7 GHz and 14.0-14.5 GHz bands need not be individually licensed. Service vendors may file blanket applications for transceiver units using FCC Form 312, Main Form and Schedule B, and shall specify the number of terminals to be covered by the blanket license. Each application for a blanket license under this section shall include the information described in §25.146.

3. Section 25.146 is amended by adding the following <u>new paragraphs (g) through (p)</u>:

§ 25.146 Licensing and operating authorization provisions for the non-geostationary satellite orbit fixed-satellite service (NGSO FSS) in the bands 10.7 GHz to 14.5 GHz.

* * * * *

(g) System License: Applicants authorized to construct and launch a system of technically identical non-geostationary satellite orbit fixed satellite service satellites will be awarded a single "blanket" license covering a specified number of space stations to operate in a specified number of orbital planes.

<u>(h) In the frequency bands 10.70-11.175 GHz, 12.225-12.70 GHz, 12.75-12.96 GHz, 13.75-13.865 GHz, and 14.0-14.24 GHz, operation of NGSO FSS systems and networks</u>

shall be limited to virtual geostationary satellite orbit systems and networks, as defined in Section 25.103(g).

~~(h)~~ (i) In addition to providing the information specified in §25.114 above, each NGSO FSS applicant shall provide the following:

(1) A demonstration that the proposed system is capable of providing fixed-satellite services on a continuous basis throughout the fifty states, Puerto Rico and the U.S. Virgin Islands, U.S.; and

(2) In the case of a non-VGSO system, a demonstration that the proposed system be capable of providing fixed-satellite services to all ~~locations~~ land masses as far north as 70 deg. latitude and as far south as 55 deg. latitude for at least 75% of every 24-hour period; and

(3) Sufficient information on the NGSO FSS system characteristics to properly model the system in computer sharing simulations, including, at a minimum, NGSO hand-over and satellite switching strategies, NGSO satellite beam patterns, NGSO satellite antenna patterns and NGSO earth station antenna patterns. In particular, each NGSO FSS applicant must explain the switching protocols it uses to avoid transmitting while passing through the geostationary satellite orbit arc, or provide an explanation as to how the power-flux density limits in Section 25.208 are met without using geostationary satellite orbit arc avoidance. In addition, each NGSO FSS applicant must provide the orbital parameters contained in Section A.3 of Annex 1 to Resolution 46. Further, each NGSO FSS applicant must provide a sufficient technical showing to demonstrate that the proposed non-geostationary satellite orbit system meets the power-flux density limits contained in Section 25.208, as applicable. And

(4) A description of the design and operational strategies that it will use, if any, to mitigate orbital debris. Each applicant must submit a casualty risk assessment if planned post-mission disposal involves atmospheric re-entry of the spacecraft.

~~(i)~~ (j) Considerations involving transfer or assignment applications.

(1) ``Trafficking" in bare licenses issued pursuant to paragraph (g) of this section is prohibited.

(2) The Commission will review a proposed transaction to determine if the circumstances indicate trafficking in licenses whenever applications (except those involving *pro forma* assignment or transfer of control) for consent to assignment of a license, or for transfer of control of a licensee, involve facilities licensed pursuant to paragraph (g) of this section. At its discretion, the Commission may require the submission of an affirmative, factual showing (supported by affidavits of a person or persons with personal knowledge thereof) to demonstrate that no trafficking has occurred.

~~(j)~~ (k) Prohibition of certain agreements. No license shall be granted to any applicant for a NGSO system in the fixed-satellite service operating in the 10.7-12.7 GHz, 12.75-13.25 GHz and 13.75-14.5 GHz frequency bands if that applicant, or any persons or companies controlling or controlled by the applicant, shall acquire or enjoy any right, for the purpose of handling traffic to or from the United States, its territories or possession, to construct or operate space segment or earth stations, or to interchange traffic, which is denied to any other United States company by reason of any concession, contract, understanding, or working arrangement to which the Licensee or any persons or companies controlling or controlled by the Licensee are parties.

~~(k)~~ (l) Implementation Milestone Schedule. Each NGSO FSS licensee in the 10.7-12.7 GHz, 12.75-13.25 GHz and 13.75-14.5 GHz frequency bands will be required to enter into a non-contingent satellite manufacturing contract for the system within ~~one year~~ eighteen months of authorization, ~~to complete critical design review within two years of authorization, to begin physical construction of all satellites in the system within two and a half years of authorization, to complete construction and launch of the first two satellites within three and a half years of grant~~, and to launch and operate its ~~entire~~ authorized system within six years of authorization.

~~(l)~~ (m) Reporting Requirements. All NGSO FSS licensees in the 10.7-12.7 GHz, 12.75-13.25 GHz and 13.75-14.5 GHz frequency bands shall, on June 30 of each year, file a report with the International Bureau and the Commission's Laurel, Maryland field office containing the following information**:**

(1) Status of space station construction and anticipated launch date, including any major problems or delay encountered;
(2) Identification of any space station(s) not available for service or otherwise not performing to specifications, the cause(s) of these difficulties, and the date any space station was taken out of service or the malfunction identified.

~~(m)~~ (n) Financial Requirements. Each NGSO FSS applicant must demonstrate, on the basis of the documentation contained in its application, that it is financially qualified to meet the estimated costs of the construction and launch of all proposed space stations in its system and the estimated operating expenses for one year after the launch of the initial system. Financial qualifications must be demonstrated in the form specified in § 25.140(c) and (d). ~~In addition, applicants relying on current assets or operating income must submit evidence that those assets are separate and apart from any funding necessary to construct or operate any other licensed satellite system.~~ Failure to make such a showing will result in the dismissal of the application.

~~(n)~~ (o) Replacement of Space Stations within the System License Term. Licensees of NGSO FSS systems in the 10.7-12.7 GHz, 12.75-13.25 GHz and 13.75-14.5 GHz frequency bands authorized through a blanket license pursuant to paragraph (g) of this section need not file separate applications to launch and operate technically identical replacement satellites within the term of the system authorization. However, the licensee shall certify to the Commission, at least thirty days prior to launch of such replacement(s) that:

(1) The licensee intends to launch a space station into the previously-authorized orbit that is technically identical to those authorized in its system authorization and

(2) Launch of this space station will not cause the licensee to exceed the total number of operating space stations authorized by the Commission.

~~(o)~~ (p) In-Orbit Spares. Licensees need not file separate applications to operate technically identical in-orbit spares authorized as part of the blanket license pursuant to paragraph (g) of this section. However, the licensee shall certify to the Commission, within 10 days of bringing the in-orbit spare into operation, that operation of this space station did not cause the licensee to exceed the total number of operating space stations authorized by the Commission.

~~(p) Earth Station Reporting. Licensees shall submit to the Commission a yearly report indicating the number of earth stations actually brought into service under its blanket licensing authority. The annual report is due to the Commission no later than the first day of April of each year and shall indicate the deployment figures for the preceding calendar year.~~